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MARCH 1935

New Power Equipment for Building Terraces - - - - - - - - - - - - *Nichols and Yoder*

Requirements of Farm Machinery for Terraced Land - - - - - - - - - - - *Ralph W. Baird*

Orchard Tillage under Straight-Furrow Irrigation - - - - - - - - - - - - *C. A. Taylor*

Strength Testing Procedure for the Agricultural Implement Type of Spoked Wheel - - - - - - - - - - - - - - - - - *O. B. Zimmerman*

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Precooling Fresh Fruits in Refrigerator Cars - - - - - - - - - - - *Gaylord, Fawcett, and Hienton*

VOL 16 NO 3

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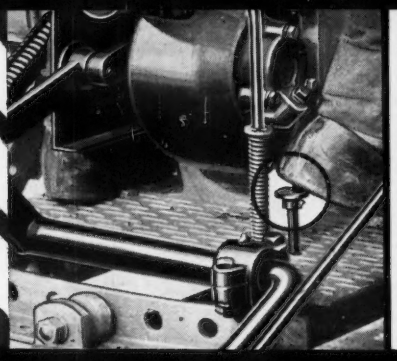
NEW MOTOR LIFT



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AGRICULTURAL ENGINEERING

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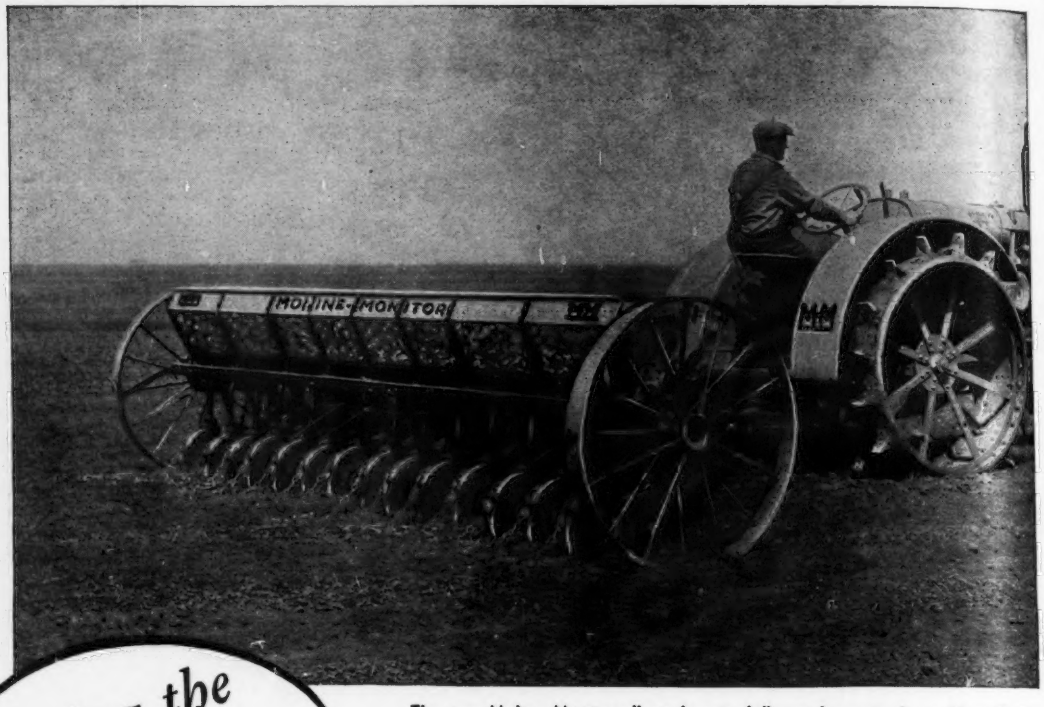

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AGRICULTURAL ENGINEERING

VOL 16, NO 3 EDITORIALS MARCH 1935

An American Tragedy: The Subsistence Farm

AMONG agricultural engineers the subject of subsistence farming seems mainly one for significant silence. As a topic, for formal discussion at least, it ranks with a half-witted brother. Lest silence be construed as assent, we hereby break the taboo.

Off the record, even an afflicted brother may inspire revealing remarks. Off the record, subsistence farming is most often branded as an effort to establish peasantry in America. Probably it is worse than that, for a real peasant at least knows how to be a peasant. As space forbids detailed citation, suffice that the peasantry aspect is most strongly emphasized by ASAE members whose duties have given them first-hand contact with European peasantry.

Advocates of subsistence farming seemingly have failed to think through to two obvious conclusions:

1 The subsistence farm family is a lost food market to legitimate American farmers, whose lost markets already are a major national problem.

2 The subsistence farm family is almost a total loss as a market for industries which already are embarrassed by partial loss of markets among existing farmers, vastly more efficient though they be.

The latter effect cannot be emphasized too strongly, even though as agricultural engineers our concern is more with the preceding point. The essence of subsistence farming is to put people where they need not buy, and where they cannot buy. What a way to restore commerce! It means that a century of progress toward an American standard of living is to be wiped out, at least for the subsistence farmer, and most of the list of necessities put back in the column of unattainable luxuries. Surely the shoe factories can see the folly of fostering a barefoot agriculture.

There has been some talk of one foot on the land and the other foot in the factory. With a self-respecting form of part-time farming that may be feasible, although experience shows that most workers want to be either farmers or factory-hands, not half-breeds. And in a conflict between human nature and economic theory, human nature usually wins.

But when we combine the idea of straddle-footing with that of subsistence farming, it comes in plain words to this: A proposal to breed a race of workers who work for nothing and board themselves. The fact of anchorage to land destroys the mobility of labor; immobility destroys bargaining power, and wages approach zero as naturally as water runs down hill. We doubt if the better sort of American industry wants any such thing, and we are very sure that red-blooded American labor will not knowingly tolerate it.

As engineers we cannot believe that any part of our national problem is to be solved by combining ignorance with inefficiency. Those are the two prime ingredients of subsistence farming.

Cooperative Farm Machinery

WHILE OLD WORLD peasantry serves as a horrible example, Central Europe is reported by some of our engineers to be far ahead of America in the cooperative use of farm equipment, notably tractors and related power machinery. Be it noted that we say cooperative with respect to usage rather than ownership. Once it is adopted as a principle to use equipment of optimum unit-size, cost, etc, as dictated by field-size, farming system, and other controlling circumstances, the manner of ownership and operation may be dealt with as a subordinate problem.

In our own country this principle is being used with excellent success in Alabama and Georgia. By joint usage, often only a few hours on each farm, these farmers enjoy the economy and effectiveness of large and highly perfected machines, and no doubt of specialized operating skill. The factor of diversity is larger and the annual hours of usage greater than usually obtain on even the largest single enterprises.

The advent of power farming, symbolized by the tractor and the combine, accentuated the traditional individualism of the American farmer. Not only the steam traction engine, but the custom sizes of gas tractors, grain threshers, silage cutters, etc., went into eclipse. Cooperative ownership and operation, typified by the "ring" thresher, were considerably checked by the development and adoption of units to match the individual farm tractor.

Besides training in cooperative marketing and other social or economic phases of agriculture, terracing programs have pointed the way toward less individualism and more efficiency in the use of equipment. This start of the pendulum back toward contract or cooperative machine operation deserves close scrutiny by our profession, and in many cases will be found to merit encouragement.

More recently, and for other reasons, the corporation or industrial type of large-scale farming went into partial eclipse. Whatever may be our views as to the social desirability of industrialized agriculture, its efficiency in the use of equipment must be conceded generally. It seems likely that this advantage may largely be combined with the social and economic stability of family-farming through cooperative usage of machinery.

Once such cooperation comes into general practice, the small farm may come into its own once more. Quite the opposite of the subsistence farm, it will take its place as an efficient producer, a worth-while market, and a desirable way of life.

From Campus to Commerce

IF, AS SEEMED TO SOME, we were grudging in our recognition of commercial interest in soil erosion control as reflected in these columns two months ago, we are amply refuted by Messrs. Nichols and Yoder in their paper published on pages 93 to 96 of this issue. Be it said for our extenuation that, in mentioning specific developments to exemplify a principle, those from academic sources seem less likely to arouse suspicion of favoritism.

There was a time when public research or development in behalf of agriculture seemed reluctant or restrained in making an ally of industry. There was a tendency to advise homemade contraptions rather than invite the benefits of commercial perfection and mass manufacture. Without taking space to list the causes of that condition, we may credit agricultural engineering in general, and the ASAE in particular, with leading the gradual change to warm cooperation between agriculture and the industries fitted to serve it well.

It seems proper to mention here the conviction, of at least part of the profession, that a middle course is most efficient and so to the interest of all parties in the commercialization of academic findings. On the one extreme is entrance by universities into manufacture or merchandising. Not only does this run into delicate questions of economic ethics, but it introduces a distracting element into the research atmosphere.

On the other hand, as one man puts it, "as a rule, the public service patent is a sure way to kill any good idea." However desirable unlimited competition may be in theory, practice indicates that competition assumes its most constructive form not inside the narrow limits of a single idea or patent, but between that idea fortified by a degree of exclusive protection plus the development and promotion such protection justifies, and other ideas or methods with which it must compete in a broad way.

How Shall They Be Taxed?

WHEN RUBBER-TIRED farm tractors begin to appear on the highways in appreciable numbers, they cannot long escape notice by tax-hungry legislators. It has been suggested that agricultural engineers should anticipate the inevitable and have ready some fair and rational basis for such taxation rather than let matters drift until enactment has begun. Some engineers deem it desirable that there be uniform provisions among the several states. We concur at least to the extent that the basis or principle of taxation should be uniform, even though the rates may vary.

Motor-truck taxation generally has been grossly unfair to the farmer. By basing license fees entirely on weight or power rating and taking no account of mileage, the effect has been to tax the farmer many times as much per ton-mile as is charged to the commercial truck operator. Not only has he paid much more per mile for using the road, but he has had poorer roads to use. Possibly—though we do not admit it—administrative difficulties forbid remedy of this inequity.

Reports to the ASAE Committee on Wheel Equipment by the minority of farmers (111) who had used their tractors for hauling, showed such usage to average 165 hr a year, and not all of it was on the road. With existing tractors this could hardly mean an average annual mileage higher than 1500, and probably means considerably less. There are plenty of truck-line units doing that much in a week. On a gross-weight basis (including load) the tractor tax should therefore be about two per cent as much as the truck tax.

As tractors are designed to take more advantage of rubber, their road speeds will increase, and with them the annual mileage. Nevertheless, the farm tractor will remain a farm machine, spending most of its working time in the fields and doubling as a highway unit only when the amount of road hauling to be done is too small to justify the fixed costs of a truck. There will automatically be a "ceiling" of annual road mileage for the farm tractor, probably of the order of two or three thousand miles a year.

Tractor engines being governed, the road speeds for which tractors are geared and governed may well be an index to their average road mileage (not necessarily in straight line relation) and so a logical factor in rate-basing. For tractors running less than ten miles an hour the annual mileage probably will be negligible, justifying no tax except a nominal fee for issuing plates, if indeed this be necessary. Such plates might well be permanent.

Maximum hauling capacity, of course, will be roughly proportional to tractor weight, but since tractors are designed and bought for other work, optimum road loadings are unlikely. Actual loadings should be studied in relation both to weight and speed. Correlated with data by similar classes showing actual mileage, it should afford a logical and fair tax formula.

As implied in the foregoing, all taxation (for regulatory or presumed road purposes) should be referred to and concentrated on the tractor itself. If license be required for the load, that is, the multiplicity of units from silo-filler to stone-boat, it would entail insufferable confusion and annoyance. After all, the aggregate ton-mileage however distributed, is a function of the tractor.

In all of this it is presumed that tractor fuel is on a tax-free basis. In that minority of states where tractor fuel is taxed, the amounts paid on field-used fuel will so overshadow the road consumption that any license tax whatever, in addition thereto, would be unconscionable.

While conceding in principle the essential fairness of the gasoline tax for road support, we suggest that states now exempting farm tractor fuel from taxation should not make haste to remove exemption from that small fraction which may be used on the highways. One reason is the confusion—which may in a few years be clarified—arising from the use of several tractor fuels other than gasoline. Another is the time-killing annoyance, not to mention the temptations, involved in measuring and recording fuel at every passage of the farmstead gate. While this difficulty might be made pretext by the tax-hungry for slapping the tax on the lion's share of fuel used in the fields, a fairer and more practical expedient would be to leave the tractor tank tax-free and, if deemed necessary, compensate by a reasonable increment in the license fee. That, however, probably would be unwarranted, especially if the average mileage of farm-owned automobiles be compared with that of others, and the unearned portion of their license fees be credited to the tractor.

Adage has it that death and taxes are equally sure. A civilized society seeks to prevent death being premature, violent, or an act of political injustice. By offering technical data and counsel, engineers may contribute to the civilization of taxes.

New Power Equipment for Terracing[1]

By M. L. Nichols[2] and R. E. Yoder[3]

THE SUBJECT of erosion control recently has been thrown into some confusion in the mind of the public by novices who have attempted to discredit the entire idea of terracing and to substitute other methods of control. While many of these purposed methods have obvious merit, they must be classed as experimental in that they generally require reorganization of established farm practices. It is highly improbable that any substitute control measures will replace terracing in the states of the Southeast. They will become supplemental to this generally accepted practice, if and when practical solutions to certain problems connected with their use have been obtained. Terracing itself is essentially sound and simple, and is based upon the practical experience of several generations of farmers. It does not involve any violent reorganization of farm practice. The construction of terraces of the proper type is the first step in any successful soil erosion control program in the states of the Southeast.

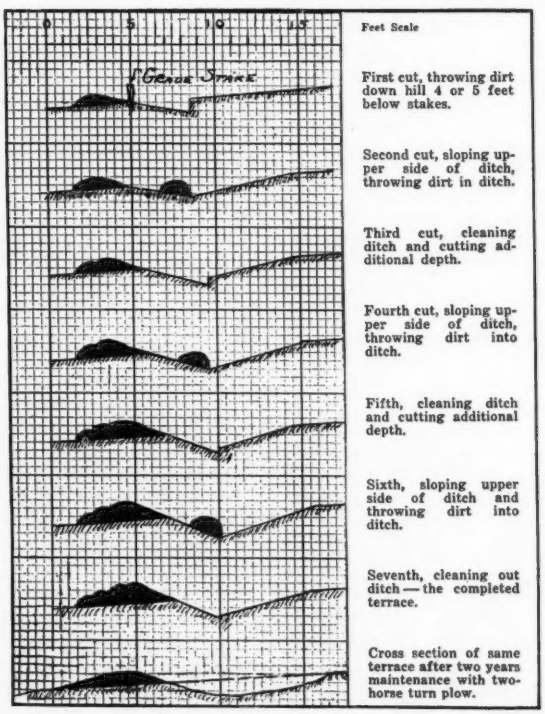
The type of terrace being used in Alabama (Fig. 1) represents the culmination of ten years' experimental work and fifteen years' experience in the demonstration of practical terracing. It has been accepted almost without exception by farmers who see it and understand practical problems involved in terracing.

With the type of equipment described in this paper, terraces are being constructed at a cost to the farmer of $10 to $12 per mile. The total acre cost of terracing, with the spacings used[4], has averaged $1.68 in the Piedmont and $1.25 on the Coastal Plain. These figures include the cost of fuel, oil, labor in laying out and checking the terraces, and depreciation and upkeep of the equipment. While the exact amount of the last item can only be determined by extensive use over a period of years, $5 to $6 per mile (50 per cent of total cost) is being laid aside to cover this item or to pay for the tractor and terracer. These figures are taken from records of farmers' bills kept by county agricultural agents.

The Southeast, until recently, has been slow to adopt mechanical power equipment, but the necessity of terracing is so keenly appreciated by the farmers that they are now organizing into local or county terracing clubs and purchasing and operating this equipment cooperatively. In most cases the county officials are supporting these clubs by financing the purchase of the equipment which is paid for by the farmers as mentioned above. It is not uncommon to see a $4,000 terracing outfit operating on a $1,000 farm.

The equipment discussed in this paper has been developed recently to meet the requirements of the cooperative program under way in the states of the Southeast. Some of the machines shown in the illustrations accompanying this paper are experimental models which were being given field tests to determine how closely they met the "job requirements" of terracing in the Piedmont and Coastal Plain regions. In the development of the equipment, the Alabama Agricultural Experimental Station workers supplied the manufacturers with the "job requirements," and the manufacturers designed and constructed the machines. The equipment was then tried out cooperatively under rather severe working conditions. In general, the equipment represents adaptations of conventional road grading equipment to the job of terracing and, therefore, has behind it many years of experience of these manufacturers.

Although the program, in its present form, is but merely started, the investment in the cooperative terracing equipment described in this paper already represents approximately one-third of a million dollars in Alabama alone. This equipment is terracing about 1,000 acres per day. It has been estimated that about two million dollars worth of equipment would be needed to complete the terracing program in this state in a five-year period. Since Alabama represents but a small portion of the area which needs terracing, and since the program is already well under way in several neighboring states and is being set up in others, the probable extensive use of cooperative equipment warrants the most careful consideration of the leaders in the field of agriculture and of the implement industry.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Feet Scale
First cut, throwing dirt down hill 4 or 5 feet below stakes.
Second cut, sloping upper side of ditch, throwing dirt in ditch.
Third cut, cleaning ditch and cutting additional depth.
Fourth cut, sloping upper side of ditch, throwing dirt into ditch.
Fifth, cleaning ditch and cutting additional depth.
Sixth, sloping upper side of ditch and throwing dirt into ditch.
Seventh, cleaning out ditch — the completed terrace.
Cross section of same terrace after two years maintenance with two-horse turn plow.

Fig. 1 Type of terrace used in Alabama, showing work accomplished by each "through"

Job Analysis

The generally accepted purpose of terracing in the Southeast is the construction of water channels of such grades on hillsides that excess rainfall will be conducted from the field without serious erosion. A few soils are sufficiently permeable to permit the absorption of practically all of the rainfall when the rate of precipitation is slow; however, frequently such torrential downpours occur that the protection of a field by storage levees or level terraces

[1]Contribution from the Alabama Agricultural Experiment Station. Publication authorized by the Director.

[2]Agricultural engineer, Alabama Agriculutral Experiment Station. Mem. ASAE.

[3]Assistant agricultural engineer, Alabama Agricultural Experiment Station.

[4]Carnes, A. and Wilson, J. B. "Terracing in Alabama," Alabama Extension Service, Circular Number 148, 1934.

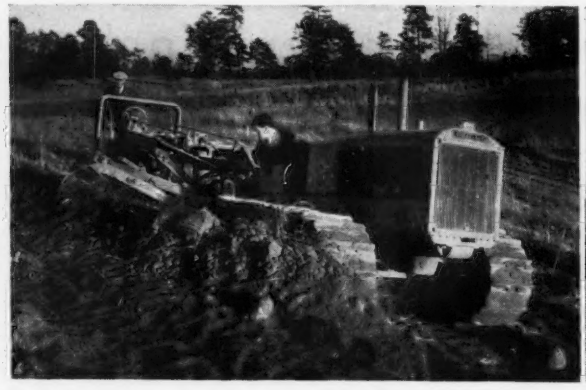


Fig. 2 (Left) The first job is to tear down old terraces. The Allis-Chalmers tractor and terracer pulls down a terrace varying in height from 3 to 5 ft
Fig. 3 (Right) Caterpillar "Diesel Forty" tractor and No. 2 terracer making first "through"

require too many large structures to make this method practical. The object of the cooperative terracing program is to provide power equipment for the construction of water channels which are wide shallow ditches. The general method of construction (Fig. 1) with the equipment described usually requires three or four rounds. These channels must be constructed quickly and cheaply, just enough work being done to bring the field safely under the control of the farmer. Methods of handling the field, which develop and maintain this ditch, are then demonstrated, using the equipment with which the farmer regularly plows his field.

The construction equipment must be sufficiently strong and powerful to move large rocks, small stumps, and other obstacles which the farmer cannot handle with the equipment which his individual farm justifies. It must encounter, without breakage, hidden stumps and rocks sufficiently large to bring a 10,000 to 14,000-lb tractor, moving at a speed of 2 or 3 mi per hour, to a dead stop. It must withstand frequent upsets on steep rocky land. Frequently a large part of the weight of the tractor is thrown on the terracer frame when slips occur in working around gulleys. It must maneuver in all kinds of narrow, steep places quickly and accurately, and turn and back close to fences or outlet ditches.

In many sections of the Piedmont poor methods and inadequate farm equipment have resulted in the formation of bench terraces varying in height from one to five feet. In many cases they must be torn down before new terraces can be constructed. Frequently the benches are full of rocks and stumps, and their destruction occupies as much as one-fourth the time of the power equipment. In general, the fields are small and irregular in shape or badly cut up with gulleys. The equipment must be designed to work in these small patches efficiently.

For efficiency, the tractor and terracer must be a matched unit. By this is meant that they should be properly proportioned in power and weight. Experience with a wide variety of equipment indicates that a 35 to 40-hp tractor and a blade terracer designed to match this power unit is approximately the right size for conditions in the Southeast. Less powerful units do not satisfactorily move the stumps and rocks encountered. To increase efficiency, the terrace would have to be constructed with fewer rounds. To do this a much larger tractor would have to be used and efficient blade equipment designed to handle the greatly increased volume of soil. While equipment of larger size has not been tried extensively in this section, calculations of the increased efficiency as compared with the increased cost do not indicate any advantage to be gained by larger equipment. The conditions of operation are not favorable, in general, to the operation of elevating graders and similar devices.

Tractors for Terracing

Type of Tractor. It is at once evident from the foregoing description of conditions that the track-laying tractor is required. This is more apparent when it is considered that the tractor is usually working on loose soil or with one track on solid soil or sod and the other on loose soil. Furthermore, this type of machine is particularly well adapted to crossing gulleys and working on steep slopes and has the remarkably advantageous feature of turning or pivoting approximately within its own length.

In order to secure stability on steep hillsides, to provide security for the operator and to insure against damage by being upset, the wide tread or hillside models are considered most satisfactory. This wide tracktread is of particular value when old terraces are being torn down. It also appears that the wider the tracktread and the greater the amount of contact with the soil, the easier the tractor can be controlled and steered on the loose soil of the new terraces.

Since much of the weight of the terracer is regularly carried on the drawbar, this must be very rigidly constructed. Frequently one-half the weight of the tractor is thrown on the drawbar when gulleys are crossed. The drawbar must be full-swinging and attached near the actual pivoting point of the tractor to permit turning under full load.

A considerable amount of pressure is imposed on the rear of the tractor due to the weight of the terracer, and the downward pull of the blade. The tractor, therefore, should have such a distribution of weight as to counteract these forces and to hold the front of the tractor on the ground when it is operating under difficult conditions such as on loose soils, over irregular surfaces, or through gulleys. While the exact minimum weight necessary for traction is a debatable question, in general, the heavier machines appear to have the advantage on loose soils provided, of course, the engines have sufficient power to spin the tracks under all soil conditions.

Size of Tractor. The tractors studied in the field varied in weight from about 11,000 to 14,000 lb, but since they varied in so many other respects it was impossible to determine just how much of their behavior was due to weight and how much to other features of design. It is considered that within this range of weights, the ordinary track cleats are quite satisfactory. The slippage of the tracks is the

safety feature in the present designs as no breakpins are provided. It was generally agreed that the tractor should develop at least a 10,000-lb pull in low gear on loose soil. This class of tractor usually has a rating of from 35 to 45 hp.

Engine Requirements. Since Diesel fuels are non-taxable in Alabama, only tractors using Diesel engines capable of satisfactorily operating on similar low-priced fuels were considered. As the tractors used for terracing must operate up and down steep slopes, the lubrication system of the engine must function satisfactorily in any position up to a 60 per cent grade.

Terracers

General Type. The general proportions of the terracer are of considerable importance as they affect stability and the smoothness of operation on uneven ground. A large amount of terracing must be performed in small fields on land having steep slopes, and, consequently, a two-wheeled terracing machine with the front end resting on the tractor drawbar is required for maneuverability. Wide-wheel tread and short overall length between the rear wheels and hitch tend to increase the stability of the terracer. Unfortunately these dimensions are limited by other practical considerations and compromises must be made. The width must be narrow enough to permit delivery of the soil outside of the wheels when the blade is working at a proper angle for handling the soil. A suitable wheel-tread has been found to be about 60 in. Since track-laying tractors are used, the elevation of the drawbar is constantly changing in relation to the soil surface when the tractor crawls over slight obstructions, as in or out of old washes. This tends to constantly raise or lower the blade. The nearer the blade is to the supporting wheels and the farther it is from the drawbar, the less is the effect of this motion on the blade. Consequently, a terracer must have a considerable length to hold this motion within reasonable limits. An overall length between the rear wheel and drawbar of 14 to 16 ft is considered a satisfactory distance.

Hitch. Due to continuous oscillations of the tractor and the constantly changing position of the terracer in working over mounds and around and through gulleys, a swivel hitch which permits the entire double jaw of the tractor to be inserted is necessary. This hitch must be heavy enough to withstand the great force of the tracks striking the frame when inexpert operators or beginners are learning to operate the equipment. A carbonized and hardened pin seems desirable.

Frame. Because of the unusually heavy strains thrown on the machines when operating on rough land, the standard frames used on road machines are not sufficiently rigid for terracers. In general, it appears that about twice the strength is required for the terracer frame as is required on that of the ordinary road drag.

In order to maintain stability, a low center of gravity is desired. At the same time, it is necessary to provide sufficient clearance for the apparatus which controls the movement of the blade. This involves either another group of compromises or a radical departure from conventional construction. From the manufacturing angle it is desirable, of course, to keep as closely as possible to power road machinery design and to use as many standard parts as possible. It was found that a ground clearance of the blade of from 10 to 14 in was ample, provided the blade could be free to rotate at this height. The blade must be constructed so that there is nothing to interfere with the rolling motion of the soil as it leaves the top of the blade. Any obstruction or parts touching the soil as it leaves the blade is apt to prevent scouring. This is particularly true of the adhesive soils of the Piedmont, Black Belt, and many of the Coastal Plains soils. For a 24-in blade of common curvature, a minimum of 5 or 6 in top clearance is necessary. The height of the grader of a given design can be easily arrived at by allowing the above dimensions for blade width, clearance, and space for the control mechanism.

Weight and Strength. It was the general opinion of designers and others who had studied the terracing job that a weight of about 4,500 lb was necessary to give the needed penetration of blade and yet not impose too great a load on the rear of the tractor. It was further estimated that the average duty imposed on the terracer is such that it must be able to withstand a drawbar pull of at least 10,000 lb.

Terracer Blades. In order to efficiently move the soil, the distance required and still to maintain enough angle on the blade to allow scouring a minimum blade length of 9 ft is required; probably a 10-ft blade is preferable. This should include the necessary end-bits which for scouring should have their surfaces flush with the moldboard surface. The blade should be about 20 in wide, including the replaceable cutting edge, and curved so that the cross section has the form of an arc of a circle. The depth of the arc for this width of blade should be approximately 4 in. This produces a rolling motion of the soil which leaves the blade in a compact mass. Pulverization of the terrace soil requires power and is undesirable. Preferably, the soil of the terrace bank should be puddled rather than loose; puddling is common practice in all dam or levee work. Packing by the tractor is beneficial.

Because of the occasional hooking of the blade on stumps and tight rocks, it was found in field trials that the blade should have a minimum thickness of 11/16 in, or its equiv-

Fig. 4 (Left) Allis-Chalmers tractor and terracer "back sloping" terrace ditch, on the second "through"
Fig. 5 (Right) McCormick-Deering Diesel tractor and Adams terracer No. 1 making third "through" of terrace

Fig. 6 (Left) Cletrac 35 Diesel tractor and Austin terracer making the fourth "through"
Fig. 7 (Right) McCormick-Deering tractor and Adams terracer making the fifth "through"

alent in the form of supporting reinforcment placed back of the blade.

Blade Control. For efficient operation of the terracing machine, it is necessary that the blade be placed in a variety of positions which can be controlled. Standard practice for blade control is through reversible worm and worm-wheels operated from a platform immediately behind the blade. Thus the cut can be quite accurately controlled as either end of the blade may be lifted or lowered. Springs with safety cables are desirable to help counterbalance the weight of the blade assembly. The blade must be capable of being set at any angle and locked from the operator's platform. This is accomplished by mounting the blade supports on a circle on which the blade can be turned by suitable devices from the operator's platform. Since the setting is done at the end of the "through," skilled operators use the power of the tractor to reverse the blade by dropping one end so that it drags around on the ground to the desired position.

The blade must be adjustable on its supports so that it can be tipped forward and backward to give desired penetration or suction and suitable movement of the soil. This adjustment is, of course, made from the ground when the machine is stopped.

Side Shift. It is desirable to have the blade so mounted that it may be shifted sidewise when the machine is in motion. In general, the greater the amount of side shift possible, the better, because this permits the grader operator to place the soil to advantage when going around sharp curves and is of advantage in destroying old bench terraces. If no side shift is available, the location of the terracer on the terrace must be left entirely to the tractor operator. Frequently, if no shift is possible, the tractor operator is under the necessity of "fighting" the furrow wall of the previous "through," which greatly increases the difficulty of his work. In any case, the tractor operator should watch the end of the blade which is placing the soil on the terrace, leaving the size of cut to the terracer operator. Proper team work between the driver and terracer operator results in better terraces and easier work for both.

General Design. Even within the limits set forth in this paper as being dictated by the "job requirements," a wide range of design is possible. The illustrations (Figs. 2 to 9) show some of the designs which have been tested in the field and found satisfactory for the construction of the type of terrace being built in Alabama. The different methods adopted by different designers to accomplish the particular jobs are shown in these illustrations. It is highly probable that improvements in design will be made as the work develops. Already there is discussion of the utilization of power from the tractor or from an auxiliary motor for controlling and operating the terracer. It is easy to get into serious arguments concerning leaning wheels, leaning frames, and other similar features. These questions, however, have been purposely avoided in this paper, as the relative merits of these elements of design must be settled by extensive field use in terracing.

Place of Equipment in Farm Program

It should not be concluded that the type of equipment discussed should replace other *(Continued on page 102)*

Fig. 8 (Left) The Cletrac tractor and Austin terracer making the sixth "through." Note the wide ditch of the terrace
Fig. 9 (Right) Caterpillar "Diesel Forty" tractor and No. 2 terracer completing a terrace with the seventh "through." Plow lines show the width and depth of the terrace

Requirements of Farm Machinery for Terraced Land[1]

By Ralph W. Baird[2]

IN OPERATING farm machinery on terraced land a number of new conditions are encountered that have not been given much attention in designing farm equipment. When a field is terraced, the normal field slope is broken up into a number of strips. Part of each strip will have the original slope, but a part of it will have a steeper slope in the same direction, and another part will have a considerable slope in an opposite direction. This means that, instead of having a comparatively smooth inclined plane to work on, we also have a number of convex and concave surfaces. These conditions are quite different when farming is done parallel to the terraces than when the terraces are crossed. For steeper slopes, crossing terraces is not satisfactory from the erosion control viewpoint and is difficult in other ways. On gentle slopes terraces can be crossed, but the effectiveness of the terrace is reduced.

In farming parallel to terraces a machine must have sufficient flexibility so that it will work well in the terrace channels and on the terrace ridge. The machine required to do this must either be divided into narrow sections or have a free vertical movement. If it is a machine that is carried on wheels, these wheels must be close to the working parts to reduce as much as possible the difference in elevation of the ground at the supporting wheels and working parts. When operating across terraces the same features are required, as in parts of the field operations will be parallel to the terraces. In addition, these machines must penetrate when crossing the terrace channel and not run too deep when crossing the terrace ridge.

This calls for a free vertical movement also, but will also require effective depth gages close to each major part of the machine in contact with the soil. In addition to these features, positive direction-control is essential, to follow crooked rows parallel to the terrace or to cross terraces at an angle. This control is difficult to obtain because of the side slip of the steering wheels and the creep of the drivewheels when on steep slopes and loose soil.

The machinery being used at the present time is not entirely satisfactory, and in some cases comparatively simple changes in construction would greatly improve the quality of work possible. In seedbed preparation, the present plows and listers are quite satisfactory, except on the steeper slopes when operating parallel to the terraces. Plows are designed for flat land and will not turn a furrow well when turning upslope on the terrace ridge or steep slopes. I believe this could be improved by lengthening the moldboard, without damage to the operation when turning downslope. Plowing and listing across terrace ridges is not recommended, but if it is to be done it will be necessary to design these machines so that they will not cut too deep when crossing the terrace ridge. Disk harrows and harrows work quite well as they are made up of comparatively narrow sections and with suitable hitches each section can be made to work independently. The Hays (Kansas) soil erosion control experiment station reports that little difficulty is encountered on hillsides of less than 10 per cent slope and on terraced land with 5 per cent or less slope for the types and sizes of machines used in central western Kansas. The one-way disk plow works very well when operated parallel to the terraces and is effective in maintaining the terrace height; if used across terraces, the width of cut should be decreased or a flexible joint should be provided near the center of the revolving disk gang.

In planting row crops most of the present machines do not have sufficient vertical adjustment and the supporting wheels or gage wheels are too far from the furrow openers and covering devices. At the Tyler (Texas) station a conventional flatland type cotton and corn planter has been remodeled so that its operation is quite satisfactory. This tractor-drawn planter had a wide tread, and the first step was to narrow the tread about 16 in by putting the fertilizer drive outside the wheels instead of inside. Then the old furrow openers and planters were discarded and replaced with two one-row planters. These planters have depth gages and press wheel cover so that the only requirement of the main frame is to hold the small planters upright and in position, being free to move vertically. In spite of a crude construction this machine is a great improvement and the class of work done compares favorably with that done with one-row, horse-drawn equipment usually used in that section.

In cultivating row crops the requirements are much the same as for planters, but positive steering control becomes of still greater importance. On steep slopes and loose soils the creep of the drivewheels may cause the drivewheels to destroy the crop in the row, even though the cultivating units are in the correct location. The narrow rim or skeleton-rim drivewheels lessen the creep, but there is still enough creep to cause some difficulty. In the cultivator, the gangs should have individual depth gage wheels, and the shovels should be as close together longitudinally as is possible without clogging difficulties.

In designing equipment for use with row crops on terraced land the section of the terrace should be considered and a width used so that it will be possible to plant and cultivate without requiring the tractor to run on the steepest part of the terrace ridge. Of course, increasing the width of the machines increases the flexibility requirements, but the difficulties in obtaining this flexibility are probably less than those in overcoming creep and loss of power when operating on the steep part of the terrace ridge.

Two-row machinery with 36 to 42-in rows or one-row machinery must work on the steepest part of the terrace ridge with widths of 20 ft or more. With widths less than 20 ft it is difficult to maintain the terrace height on cultivated land. With the two 42-in rows on top the ridge of a 20-ft terrace, the machine would be almost level, but the adjacent pairs of rows are on the steep part of the ridge. If the two upper rows on the side of the ridge are worked together, these two are on the steep part of the ridge, but the two below work quite well. With three-row machines the machine can run on top of a 20 or 25-ft ter-

[1]Second part of a paper presented at a session of the Power and Machinery Division of the American Society of Agricultural Engineers held at Chicago, December 3 and 4, 1934.

[2]Associate agricultural engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Jun. ASAE.

race and the adjacent three rows are just below the steep part of the slope.

It may be that other special machines will be required on some of the terraced land. If land is broken a number of years in succession, backfurrowing to the terrace ridge, a deep deadfurrow is formed between terraces. There is also considerable movement of soil downslope between the terraces. If we can turn all of the furrows uphill, leaving the deadfurrow in the terrace channel each year where the movement of soil downslope will tend to fill it, we may be able to partially overcome the erosion action by one of the regular farm operations. At the Tyler station on land in cotton, the channels of nine experimental terraces had an average fill of 0.104 ft, or an area of 0.794 sq ft. One furrow slice of a 16-in plow 7 in deep is 0.778 sq ft, and if it could always be thrown in a direction opposite to the normal soil movement, it would almost balance the natural movement of the soil. This will call for the use of a two-way plow on terraced land, and work of this kind is planned for the Tyler station.

To summarize the requirements of farm machinery for terraced land we can list the following: (1) Flexibility in a vertical plane to allow for the unevenness of the ground surface; (2) compactness longitudinally, to follow crooked rows and reduce the effect of an uneven ground surface; (3) positive steering; (4) wheels and lugs designed to reduce creep as much as possible; (5) a low center of gravity; and (6) selection of widths that will make the operation of the tractor on the steepest part of the ridge unnecessary.

(ACKNOWLEDGMENTS: The author wishes to acknowledge the assistance and data received from R. R. Drake at the Hays (Kansas) station and H. S. Riesbol at the Guthrie (Oklahoma) station in preparing this paper.)

Discussion by Raymond R. Drake[1]

TILLAGE, seeding, and harvesting implements consisting of plows, listers, harrows, drills, planters, cultivators, headers, combined harvester-threshers, and the track-laying and wheel-type tractors have been used parallel and across terraces in straight rows on the Hays (Kansas) soil erosion experiment station.

The farm implements furnished to the regular farm trade are generally fairly well adapted to the terraced areas on less than 4 or 5 per cent slopes. Above the 4 or 5 per cent slopes the difficulty rapidly increases. The greatest trouble encountered is being unable to adjust them to the uneven ground surface, especially while crossing the terrace ridge and channel.

The harvesting equipment can operate over the same areas to a better advantage in any direction than the tillage and seeding equipment. The tillage equipment usually gives more trouble than the seeding equipment over the same area.

Lister. The standard 2 and 3-row listers will operate between terraces and maintain a uniform ground elevation, but when crossing a ridge or depression some of the lister bottoms will penetrate very deeply and some may even be above the ground surface. Such listing is very destructive to terraces and a poor quality of tillage is accomplished. The 3-row listers of two leading manufacturers are of this type and are mounted in a single unit.

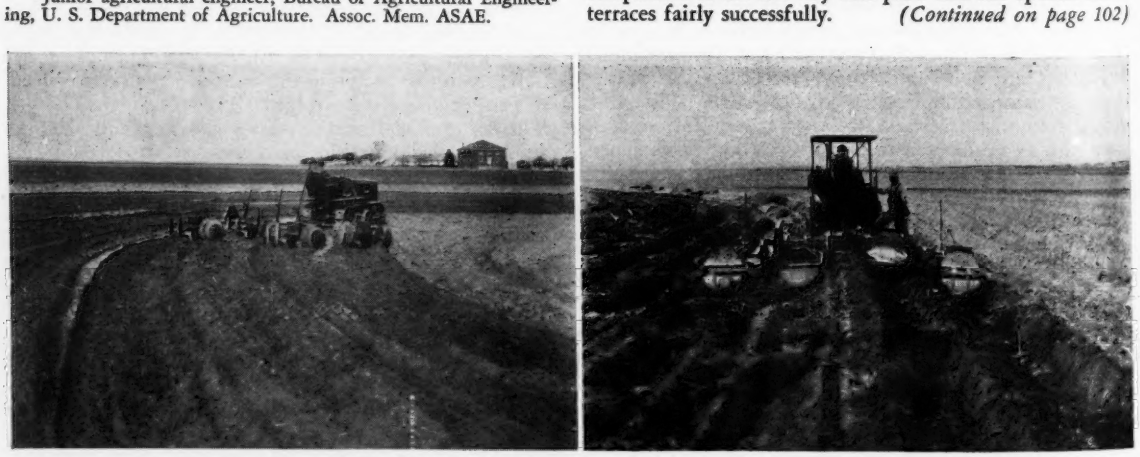
There is a one to five-row lister on the market with independent lister beams. Each unit is individually controlled, and all units are controlled by a single lever. The carrier wheels of each unit are located as close as possible to the shear, thus permitting automatic uniform penetration of each unit regardless of the adjacent unit. This type of lister is excellent for tillage either parallel or across terraces, and it is doing quality work at the Hays station.

Ridge Buster. To obtain the best results in sledding or busting the lister ridges, the ridge buster should be able to follow either a straight or crooked row and maintain a uniform depth regardless of the adjacent units. The independent unit type of ridge buster has been found to be the best suited for crooked rows, able to cross terrace ridges and each unit staying in the furrow. The 4-row ridge buster of this type is doing quality work on the Hays station.

One-way Disk Plow. The one-way disk plows are all constructed on the same principle. The solid-unit construction is an advantage in maintaining terrace height and width. The plow is able to cross a terrace in one direction only without lowering the top of the terrace ridge. Therefore, the one-way disk plow must operate parallel to terraces, or the rolling disk gang should be constructed with a flexible joint to conform better with the ground surface. The 8-ft plows appear to be about the proper width of cut for terrace maintenance.

Tandem Disk Harrow. The tandem disk harrow works equally as well in either direction, maintains an even ground surface, is more flexible, and larger sizes may be used in comparison to the one-way disk plow and can operate across terraces fairly successfully. *(Continued on page 102)*

[1]Junior agricultural engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Assoc. Mem. ASAE.



(Left) A 4-row ridge buster taking a very sharp turn and doing excellent work. (Right) A 4-row lister with basin attachment on a terrace ridge. Notice how well the lister conforms to the terrace ridge and maintains a uniform depth of tillage

Orchard Tillage Under Straight-Furrow Irrigation[1]

By C. A. Taylor[2]

ORCHARD TILLAGE is not always an essential operation. It is possible to produce most tree crops successfully without cultivation of the soil. The general practices of deep tillage and frequent cultivations of some years ago have been greatly modified. It has been demonstrated that the benefits from a complete turning under of a cover crop or deep mixing of bulky organic fertilizer are offset by the harmful effects of root pruning. Cultivation for water conservation must be limited to the control of weeds also, since the theory of soil mulching to reduce water losses has been disproved. Stirring the soil, especially when it is moist, breaks down its structure and reduces the capacity of the soil to absorb water. Hence, the present tendency is toward a minimum of cultivation.

Straight-furrow irrigation is widely used in orchards. It is particularly adapted to land with a slope of one foot per 100 ft or greater. On flatter slopes where large heads of water can be used some method of flooding with borders or a combination of cross-furrows and borders appears to be most successful. On the steeper slopes water can be controlled more easily when it is distributed in furrows.

It has now become rather common practice to use the same furrows or checks two or more times without cultivating. However, where the water supply is limited, weed competition must be controlled during the irrigation season. Where straight furrows are used, it is possible to control weeds effectively without breaking down the furrows. This method of tillage combines the two main functions of cultivation by controlling weeds and preparing the land for irrigation in the one operation. It was first used by the Division of Irrigation of the Bureau of Agricultural Engineering of the U. S. Department of Agriculture to improve the water penetration in the hardpan of citrus orchard soils[3].

The method has been developed still further and its advantages are found to lie in a more efficient use of the fertile top soil, an increased efficiency in irrigation, and better control of runoff and erosion. Fig. 1 indicates how the broad shallow furrows are laid out and maintained in a fixed position for the entire season.

It is desirable to use as many furrows as possible in order to gain the best distribution of water and nutrients in the zone of greatest feeder root concentration. With a large number of furrows water is not necessarily applied in every furrow at each irrigation. It may be applied in alternate furrows, in alternate groups of furrows, or even between alternate tree rows. This is sound practice, as it has been shown in experiments with lemon trees that there is a ready cross-transfer of water throughout the tree and that any root may deliver water to any branch[4]. Hence, alternate irrigation offers a safe means of drying the soil down close to the wilting point. This permits relatively long intervals between wettings of the soil—a desirable thing from the standpoint of efficiency of irrigation. From the standpoint of tillage, irrigation between alternate tree rows is the best alternating system when the furrows run north and south. There is then less danger of traffic on wet soil than when alternate furrows are wetted. When the furrows run east and west, the best plan may be wetting alternating groups of furrows, first on the south side and then on the north side of the tree row. Cultivation is then done just prior to the irrigation of the group of furrows on the north side of the tree row. This allows the maximum time for the soil to dry out in the group of furrows on the north side where the soil is shaded.

Aside from tillage for irrigation and weed control, fertilization is the remaining orchard operation for which cultivation is essential. For incorporating bulky organic matter into the soil, the disk harrow is widely used. In most groves the cover crop or weed growth is disked under as soon as the ground is dry enough to be worked in the spring. Large offset disk harrows with 22-in blades have come into general use during the past ten years. These tools are capable of moving a lot of dirt. The best cutting action on the cover crop is obtained with the disks set at a large angle with the consequent tendency for deep penetration. The soil is softer under the tree and this fact, as well as the inherent tendency for the leading gang of disks to dig in at the concave end, is responsible for the disturbing and pulling away of much soil from under the tree. To correct this condition and obtain a more uniform penetration, rollers or depth gages are now being generally used in California[5]. Twelve-inch rollers are used with 22-in blades in order to limit the cutting depth to not more than 5 in.

Few growers have maintained their land in a uniform grade and obtained full use of the most fertile top soil. Where the offset disk is used there is a tendency to move the soil away from the tree and ridge it up in the center. Erosion is active in varying degrees on the steeper slopes so that the contour of the land becomes irregular. Hence, it is generally desirable to float or regrade the land before laying out permanent furrows. Uniformly graded land is necessary if shallow furrows are to be used.

When the furrows are first laid out in the spring it may be best to mark the center of the rows with flags so that the tractor can be driven straight down the center of the lane midway between tree rows. This is especially helpful when the tool may be working close to the tree trunks and out of sight under the branches. Once the furrows are fixed in position the ridges between the furrows become firm and the tool thereafter tends to follow in the established furrows. This is indicated in Fig. 1 Seven furrows are used in the orchard shown in part in the illustration.

For the implement shown in Fig. 1 the sweeps for making the furrows and controlling the weeds are mounted on a low carrier-beam designed for work under low-hanging branches. Seven sweeps of the same type are used with

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[1]Paper presented at a meeting of the Pacific Coast Section of the American Society of Agricultural Engineers at Corvallis, Oregon, December 1934.

[2]Assistant irrigation engineer, Bureau of Agricultural Engineering, U. S. Department of Agriculture. Mem. ASAE.

[3]C. A. Taylor, Water penetration in hardpan citrus soils, AGRICULTURAL ENGINEERING, vol. 15, no. 6, June 1934.

[4]J. R. Furr and C. A. Taylor, Cross transfer of water in mature lemon trees, Proc. Amer. Soc. Horticultural Science, 1933.

[5]J. P. Fairbank, Attachments for disks to control depth of tillage, University of California Agricultural Extension Service, Agricultural Engineering Series, No. 4.

three mounted ahead of the beam. The furrows occupy a space 16 ft wide, and the sweeps contact practically all of this soil surface with one trip to the row. Weeds are cut off at the ground surface as the sweeps pass through the furrows. A carrier-beam 12 ft long is used, and the two outside sweeps are mounted on shanks that may be thrown back for turning in restricted spaces. This low-beam type is especially advantageous in citrus orchards where the branches are close to the ground and there is much low-hanging fruit. Its chief disadvantage lies in the difficulty in turning.

Furrow sweeps for use on standard wheeled carriages are shown in Fig. 2. In citrus orchards the height of the carrier-beam is objectionable on the standard heavy-duty carriages because of the damage to low-hanging fruit. It should be possible to modify the method of mounting the carrier-beam to overcome this objection.

A 15-hp tractor is required in order to make or cultivate seven furrows in one trip per row. With less power fewer furrows must be cultivated. However, one of the principal advantages of this method of cultivation lies in centering traffic midway between the tree rows. With the center furrows spaced 28 in apart, wheel traffic naturally follows in two furrows at the standard tread of 56 in. It is necessary, then, that the tread on cultivator carriages be 56 in in order that the wheels may follow the bottom of the furrows so that the sweeps will run true. Confining the traffic to these definite lanes is an important advantage. The remaining portion of the cultivated strip of soil can then be worked with offset or outrigged tools and all heavy traffic on it be eliminated. The damage caused by traffic to the soil structure has been and still continues to be a problem. This is especially true in the citrus areas where the ground is never frozen.

The compaction of the soil causes irregular penetration of water and impairs the efficiency of irrigation. Farmers have been advised to leave furrows open and permit weed growth in order to improve the capacity of the soil to take water. In many instances this has been so successful that a new problem has developed. The soil becomes so permeable to water that excessive losses by deep penetration occur before the lower end of the grove can be properly irrigated. When it is attempted to increase the head of water in a furrow in some soils serious erosion develops. Some growers have then tried cultivating the upper end of the grove when the soil was wet in order to get water to the lower end without serious erosion or excessive deep penetration. However, the confining of traffic to two definite furrows offers a solution of this difficulty. These 2-wheel furrows can be used as lead-ditches and water carried down them and "cut in" to the more absorptive furrows at different points along the length of the row. The unavoidable compaction of the soil in these two furrows is in this way put to work and made to serve a useful purpose. The division of water between furrows at points away from the head-stands may offer some difficulty but a practical way to overcome this is to use pea gravel at the points of division. A small amount of gravel sprinkled in the furrows at the points of division holds the set of the division. Some growers in the Pomona area use this means of dividing water between a number of furrows at the head-stands. When furrows are placed in under the trees, it is essential that "cut-ins" be used or additional pipe lines laid and very short runs used. Water cannot be run to the lower end of the usual length of furrow, 300 ft or more, without over-irrigating the upper end, particularly when furrows are placed in under the trees. For instance, in one orchard where the furrows were 300 ft long, there was only enough water for one furrow in each row. The same head of water was sufficient for three furrows after it was carried down the wheel furrows and cut in at two points along the run, while under the old method there was excessive deep percolation at the head of the furrows.

Practical experience in the irrigation of citrus orchards has shown that trees may be damaged by overirrigation. For high efficiency in irrigation, the water must be spread uniformly over the land. This can be done by the use of a relatively large number of broad, shallow, permanent furrows, and by the use of short runs, or a system of cut-ins to inside furrows. If proper efficiency in irrigation is attained, the problem of overirrigation will naturally be taken care of.

There is still possibility for better conservation of rainfall even though many sections of the West rely principally on irrigation. Increasing losses from rainfall runoff and erosion must be charged directly to cultivation practices. Furrow-irrigated orchards lose great quantities of top soil during each major storm. Sheet erosion occurs, gullies are cut, and low-lying orchards and highways are strewn with debris. Yet how many farmers place the retention of the water-absorbing power of the soil as the number one objective of their cultivation practice? The number is as yet very small. This objective is too obscure—other operations have more immediate and apparent value. Some farmers still cultivate for the sake of cultivating and, for various reasons that seem pressing at the time, the majority still cultivate soil when it is too wet. Picking, firing, spraying, and fertilization operations must go on. They are often done when the soil is wet enough to be compacted. Many citrus orchards are clean cultivated in the winter to facilitate firing operations and to gain the degree or two higher temperature for low-hanging fruit that clean culture gives over heavy cover crops. It must be admitted that some of these operations at one time or another will come when

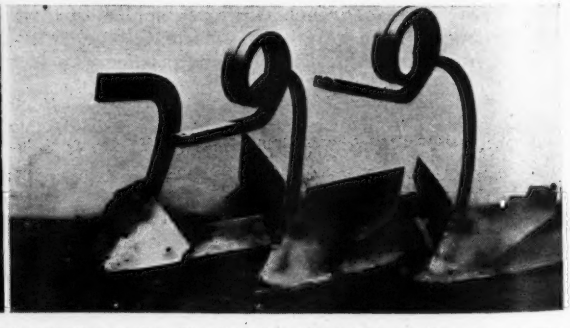

Fig. 1 (Left) Furrowing implement for making broad, shallow furrows and controlling weeds. Fig. 2 (Right) Weed-knife attachments on furrowing shovels for use on standard carriages

the soil is wet and cannot be avoided. We must accept the fact that the central part of each lane will be more compact and less absorptive than the area under the trees and along the tree line. But traffic can be held to a minimum and especially avoided when the soil is wet. Cultivation should come just before irrigation rather than after. This is especially necessary when furrows are placed in under the branches of the trees where the soil is shaded and the surface dries out slowly.

A vegetative cover is the most potent influence in maintaining the infiltration capacity of the soil. Organic matter in the soil not only maintains fertility but keeps the soil absorptive. If cover crops are not grown, organic matter should be added and incorporated mechanically. Barring hardpan or plow-sole conditions, water absorption depends chiefly on the surface condition of the soil. Hence, bulky organic matter should be thoroughly mixed with as shallow a layer of soil as practical. For protection again winter rains it should be applied in the fall. Under the permanent-furrow system of cultivation described in this paper, organic matter should be spread in the furrows, the soil may be disked lightly, and then immediately furrowed out again. Maintenance of infiltration capacity and control of run-off and erosion are essential features of this method of cultivation.

On some soil types the infiltration capacity is high and runoff rarely occurs from the furrows next the trees. To control runoff from the center furrows under such conditions, water from the more compacted central portion of each lane is diverted into the more absorptive furrows along the tree lines. The diversions are made about every 100 ft along the row. Runoff from rainfall is thus intercepted near its source and spread onto absorptive soil, loss of water from the grove is decreased and erosion checked. When the soil type is such that general runoff is apt to occur from the entire area, there is no advantage in making the diversions.

Having the soil surface formed into permanent furrows helps further in checking erosion since loose, cultivated soil is much more easily picked up and carried away. The erosive power of a stream of water varies as the square of the velocity. The weights of particles that can be transported vary more nearly as the fifth power of the velocity. Hence, loose soil in steep-sided furrows is easily transported away since it can be picked up by undercutting. Firm soil in broad, shallow furrows erodes much more slowly.

To check erosion, it is essential to keep the velocity of the runoff water at a minimum. Velocity varies according to the formula

$$V = C\sqrt{RS}$$

where V = velocity in feet per second

R = the hydraulic radius (the cross-sectional area divided by the wetted perimeter of the channel)

S = the slope of the water surface

C = a constant depending on S, R, and n, where n is a coefficient that varies with the roughness of the channel.

In most established orchards, S is fixed by the layout of the irrigation distribution system and is difficult to alter.

R may be reduced by decreasing the cross-sectional area of the stream or by increasing the wetted perimeter. This is accomplished by increasing the number of furrows and by making them broad and shallow.

$$C = \frac{\dfrac{1.811}{n} + \dfrac{41.65}{} + \dfrac{0.00281}{S}}{l + \left(41.65 + \dfrac{0.00281}{S}\right)\dfrac{n}{\sqrt{R}}} \quad \text{(Kutter's formula)}$$

C may be decreased by increasing the value of n. This is most readily accomplished by permitting vegetation to grow in the furrows. The value of n for a channel with vegetation growing in it may be more than double that for a similar clean channel[6]. The value of n may be increased by spreading bean straw or hay in the furrows. This method is useful where the cover crop is not wanted because of firing operations and temperature control, but the effect is not as great nor as lasting as growing vegetation. With bulky organic matter, the greatest improvement in the infiltration capacity of the soil is obtained after a light disking. However, a portion of the organic material could be saved and spread in the furrows after they are remade. Tests conducted by the USDA Bureau of Agricultural Engineering at Pomona in 1933 showed no measureable decrease in velocity or increase in the absorption rate in furrows when alfalfa hay was dropped into furrows that were already carrying water, except where the furrows were so steep that they were eroding severely. While litter in the furrows may increase the value of n only slightly, it will aid in protecting the soil from the beating action of heavy rains. It is most effective after some weed growth has penetrated through it. From the foregoing, the velocity of runoff may be best controlled by using a large number of broad, shallow, permanent furrows and by permitting vegetation to grow in the furrows during the rainy season.

Years of light rainfall with no perceptible runoff and erosion from groves on soils of recent origin lull the operators into a false sense of security. Where runoff is occurring every year the problem is more in the limelight. However, every orchard should be prepared to care for excess runoff that may occur in major storms. Permanent furrows are a good protection against cross-slope break-overs. Firm ridges between the furrows help to keep the water confined to the proper channels. Cross-cultivation should be limited as much as possible. It might well be discontinued in the fall or winter in the citrus orchards of California. It may be the most economical way to control weeds on the flatter slopes, but if the cross-slope is three or more feet in 100 ft, it may be well to eliminate cross-cultivation entirely. It is possible to reach all but a very small area along the tree lines by one-way straight-furrow cultivation. Noxious weeds on tree lines may be controlled by hand work. The added protection of absorptive uncultivated strips of soil along the tree line is very much worth while from the standpoint of rainfall conservation and protection against erosion.

Wherever water collects at the ends of furrows, provisions should be made to protect the course it takes to main drainage channels. The outlet ditch collecting water at the ends of furrows should be very broad and shallow. Such channels should be kept with a permanent cover of vegetation. If there is any tendency to gully, the bottom should be cross-checked to keep the water spread out. If a grove is located on particularly shallow soil, it may be desirable to use vegetated soil-saving basins at the end of each row so that the eroded soil can be caught and hauled back to the orchard. Community problems of drainage and highway

[6]C. E. Ramser, Dynamics of erosion in controlled channels, Transactions of the American Geophysical Union, 1934.

maintenance would be greatly lessened if every grove were properly protected against erosion.

In summary, changed ideas concerning the fundamental requirements of orchard cultivation have necessitated changes in implements used to perform orchard tillage operations. There are many orchard operations that conflict, and careful planning is required to bring tillage into accord with all other phases of the orchard program. Disks must be designed to give the maximum cutting action on cover crops with uniform and shallow penetration. Under straight-furrow irrigation the control of weeds and the preparation of furrows for irrigation can be combined into one operation. Implements to combine these two operations are being developed. This makes the use of permanent furrows feasible, and they can be made broad and shallow so that more of the fertile top soil is available to feeder roots. Water can be spread over the land more uniformly and a high degree of efficiency in irrigation can be obtained. When this is accomplished, the problems due to overirrigation are automatically taken care of. Rainfall is conserved by diverting the runoff from the more compacted soil and spreading it onto the more absorptive area along the tree lines. This aids in the control of erosion and leads to a more permanent agriculture.

New Power Equipment for Terracing

(Continued from page 96)

machinery for terrace construction where terracing is part of the regular farm program. On many farms where tractors are available, smaller equipment such as the Corsicana, Texas, Martin, and Caterpillar No. 1 terracers have proven themselves valuable units. A number of years ago the Alabama station developed a method[5] of building the same type of terrace with the wheatland plow. This implement, when properly utilized in a "delayed" or progressive development of the water channel in connection with the regular plowing program, was found to be very effective in the construction of terraces. It had the advantage of being part of the regular equipment used in farming in certain sections. Since the type of tractor necessary to pull this plow is not used in the Southeast very extensively, no great area has been terraced by this means.

The equipment described in this paper, however, does not depend for its profitable use on any reorganization of the farm power program, such as does the use of the general farm tractor, and, consequently, the only question involved is the most efficient unit for one specific job. The ready and enthusiastic reception given by the farmers themselves forces the conclusion that the equipment must be approximately right in their opinion; in practice they are both judge and jury. It is possible that this attitude on the part of the farmer marks the beginning of a new power program for the states of the Southeast.

[5]Randolph, J. W. "Nichols Terrace," Country Gentleman, June 1928.

Requirements of Farm Machinery for Terraced Land

(Continued from page 98)

Drills. Drill width should not be wide. A 12 8-in disk seems to be of ample size. The larger size drills do not conform to the ground surface. The wheels carrying the drill weight should be in line with the disks penetrating the ground, and packer wheels should be as close as possible to the disk. A staggered disk arrangement may be more desirable.

Planters. The independent planters similar to the principle used by the type of lister and ridge buster previously mentioned appear to be better than the present two and three-row planters.

Cultivators. The observations on cultivators are very limited.

Mowers and Rakes. The longer the sickle bar the more uneven the cutting will be. The same applies to rakes.

Headers and Combines. The header, swather, and combine cutting platforms are similar for all makes. The combine is not the awkward, clumsy machine that many believe. The popular machine is divided into two distinct types: one with a flexible floating platform, and the other in which the cutting platform and separator are mounted as one solid unit.

The machine with the floating flexible platform can cross rather steep terraces at any angle and maintain an even height for the platform. It is not possible to do so with the solid unit.

The floating platform sickle is usually mounted about midway between the front truck and main wheels of the separator. The platform in the middle location is able to maintain an even height when the separator wheels are passing over an obstruction or in a depression.

One make of combine has a very high separator clearance between wheels, a very desirable feature. Another make has a very low clearance especially when cutting high, because the fan house is mounted low and the separator is counterbalanced with the platform. When the platform is raised to pass over an obstruction, the separator and fan house is lowered closer to the ground and may strike obstructions, causing damage and delays.

Tractors. A wheel-type tractor is able to travel over and across terraces easier and with more comfort to the operator than the tracklaying type. The disadvantage of the wheel type is the digging in and not being able to travel along the lower terrace side. The advantages of the tracklaying type are: (1) It is able to cross terraces and not dig in, and (2) it will hold its place better and will not stall in the wet terrace channels. One type will probably tip over as soon as the other.

Another Use for Clay

CLAY IN CONCRETE? That suggestion, if made a few years ago, would probably have elicited exclamations of horror from men who professed to know the scientific side of mixing cement and aggregates together to form this building material in such universal use. Yet it was suggested as a possible research to the producers of clay by no less a person than Professor J. R. Shank, the Ohio Engineering Experiment Station chief researcher on concrete.

The great improvements in cements during the past decade, since Abrams devised his famous curve, have prompted investigators, among them Straight of Iowa, to suggest the addition of finely ground clay to concrete, where smoothness of mix is important, but where the maximum strength is not required. Nowadays concrete in huge masses, if made with enough cement to work easily and fill all the voids, is really stronger than necessary. Properly prepared, that is, very finely ground clay may turn the trick of making concrete that is smooth and impervious and still strong enough.

Strength Testing Procedure for the Agricultural Implement Type of Spoked Wheel[1]

By O. B. Zimmerman[2]

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JUDGING from the approving letters received since publication of the paper on stress surges in loaded wheels in this journal[3], this subject has created an unusual, pleasing, and widespread interest in all wheels considered as a structure. This interest shows itself equally in methods of manufacture to produce improved wheels, and the research testing methods to check and assure results.

Inasmuch as only a part of the whole problem covering the technical features could be given in the paper just referred to, it seems desirable to continue that interest next with a discussion of laboratory methods used, or to be used, to secure practical checks on this technical approach, with the further view of developing a standardized practice in the art of wheel design, production, and testing.

For this general reason, wheel-testing procedure seems now to be the most important one to develop. This technical series has yet to cover wheel hub stresses, sidethrust strains, torsional and pivotal activities, wheel manufacturing methods, materials, inspection and control, modifications of the developed formulas necessary to include high-speed effects and the introduction of the inertia factor, modifications to meet factors involved in other than implement type structures, and, finally, wheel design, making full use of the entire review.

The history of wheels and their evolution is full of interest, both popular and practical, and deserves whatever of time and expense it will take to do the job thoroughly.

Having thus scanned the horizon, we can now centralize on the immediate subject of the engineering research testing of wheels.

General

It is important to record here that engineers and many others interested in commercial development have in the past been too easily satisfied with the common simple axial tension, compression, shear, bend, or torsional test-piece results. Small rods, bars, or samples, when tested, have given results which were the principal basis for construction or design. While this procedure bears the apparent merit of low expense, it too often amounts to "going through the motions," without reaching the maximum results attainable.

When combined units are under test, when junctural connections, part to part, and eccentric loads are involved, this elemental testing is entirely unsuitable to use alone as a designing guide and thus jeopardizes mass production and field use; hence, management must be convinced of the legitimacy of devoting both time and expense to a larger program. This is warranted if adequate results, low overall cost, and the elimination of much back-tracking and delays for revamping are desired.

The analysis of actions, reactions, moments, stress surges, and the influence of impressed stress thereon was clearly shown to be of extreme importance in the preceding paper[3]. They have, in fact, a profound bearing on the problem and must not be casually pushed aside. It is now unquestioned that the following through of direct stresses in one line or one plane is not sufficient. All in all, this scramble of stress involvement and space geometry of design in many products has been the basis, in the past, for the common saying "Our problem is different; the only test is the field test." That is a path out, but not an answer. True it is that the final test is in the field, but a very high percentage of the problem can be disclosed and solved under proper testing conditions, under controlled influences and measurement, which procedure logically pursued leaves less hazard ahead of production and certainly advances the date of complete and confident acceptance of a product.

This wheel test problem is thus disclosed as being one far from a test-bar simplicity. To simulate in the laboratory all the variable surges of major stresses, which in the field are caused by load thrusts, lurches, plunges, speed and footing variables, would be a very complicated problem indeed.

Wheel Testing

The objective in laboratory wheel testing must be along the line of disclosing the required maximum and minimum limiting values and the balance of strength to be met against the major group stresses for the specific activity of the field, and it must be such as will insure that this maximum value and the balance between the major stresses to be met will be maintained throughout its useful life.

The art of designing wheels should involve suitable maximum strength, minimum weight, reasonable cost in accord with known requirements, and should insure a reasonable repair replacement.

The economics of the problem, in fairness to all interested parties, producer and consumer alike, should acknowledge another thought, namely, that all wheels need not be so strong as to meet every possible abnormal or exceptional, accidental, excessive stress, or wear and tear, because that would involve a sacrifice of the many users to the few. Reasonable replacement is therefore permissible, but tests must disclose whether breakdowns are the result of stress values exceeding the elastic limit, or whether they are due to correctable design or manufacture.

It is good judgment in any field, when passing from empirical development to that of technical control, to use as a prime basis for design data the available information contained in the vast number of products built in the past which have a record of practical serviceability. They have stood the test of time, but if, as in this case, we can take from them the average mass strength data, and then attempt to build equally serviceable wheels which meet the technical indications of possible improvement—this at equal or less cost—we are serving an economic end with wholesome engineering.

Under test a well-designed and constructed wheel should run indefinitely under its normal loads, hence the necessity of devising combinations of excess load and excess speed in order to bring the test period within the range of a timely

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[1]Paper presented at a meeting of the Power and Machinery Division of the American Society of Agricultural Engineers at Chicago, December 3 and 4, 1934.

[2]Consulting agricultural and mechanical engineer, Chicago. Mem. ASAE.

[3]A Technical Analysis of the Agricultural Implement Type of Spoked Wheels, by O. B. Zimmerman, AGRICULTURAL ENGINEERING, August 1934, Vol. 15, No. 8, pp. 287-301.

decision. This is recognized as an accelerated test and must therefore be subject to reasonable control ranges. Standardization calls for some relationships being established between the multiple-load factor or factors and the multiple-speed factor or factors, which will by comparison give us a gage of what the samples would do under normal loads.

Two classes of tests are desirable—those termed "static," in which the structure remains stationary under increasing loads set in testing equipment wherein the load-deflection data are measured intermittently or continuously up to the elastic limit, or to destruction as the case might be, and those termed *dynamic,* in which loads are applied in various ways while the wheel rolls. Combinations of multiples of normal load and normal speed are applied up to the point of indicated unserviceability, incipient destruction, or complete crashing, as is desired. Periodic careful inspection is also implied throughout the tests.

In both static and dynamic tests, the prime group stresses selected thereunder for implement wheels are those of (1) radial load, (2) side thrust, (3) torsion, (4) pivot, and (5) internal stress. They need no close definition at this point as they are obviously distinct.

In the field, combinations and shifts of these stresses over a wide variation are always present, but the value of making tests which would duplicate all such surge combinations in measurable form is not great enough to warrant the expense. When we have data under the five major activities, we can determine all we normally shall need through known mathematical relationship of combined stresses.

Basic Data

Since no engineering data was available of record before these tests were made, it was necessary to develop basic values from the resistance or endurance of empirically developed wheels. It was therefore deemed best to proceed by a series of competitive group tests, using typically good wheels, made for a like purpose and capacity. These wheels were put under static and dynamic tests as outlined above. Wheels of various manufacture were used.

The average and maximum efficiency data of this review was used to guide us to a point where prejudging the possibilities of a wheel type in measured values is possible. It also gave us sensible minimum test values to attain.

If the reader is reasonably familiar with implements, the field requirements of the several wheel types, such as are used on rakes, drills, cultivators, plows, corn planters, tractors, grain binders, mowers, manure spreaders, ensilage cutters, threshers, etc., present rather generally defined distinctions. In each of these we see emphasized requirements of relationship between the selected radial load and side-thrust, torsional, pivotal, and impressed stresses, but as engineers we need these distinctions defined more exactly in related strength values.

TABLE 1. STATIC TESTS

Wheel types	Avg. load per lb wheel	Radial load, per cent	Side thrust, per cent	Torsion, per cent	Pivot, per cent
24″ Plow, furrow	326	100	32.0	20.3	35.2
30″ Plow, furrow	426	"	8.9	11.6	14.0
30″ Planter	119	"	10.4	21.2	16.9
36″ Planter	88	"	10.7	18.8	18.2
42″ Cultivator	106	"	25.0	25.0	27.0
48″ Drill	91	"	14.2	17.9	13.2
30″ Spreader, ft	246	"	16.0	10.8	18.6
30″ Tractor, ft	216	"	30.0	42 1	16.1
42″ Spreader, rr	98	"	22.2	10.8	13.3
40″ Tractor, rr	108	"	32.0	37.2	14.6
Grand avg.	182.4	100	22.31	21.93	16.06
Greatest variations	133.2+%		43.4+	70.0+	119.2+
+ & — %	51.7—%		60.0—	50.4—	15.95—

In the forthcoming paper on wheel design, more data will be given of this nature.

Individual type wheels normally run much closer to a grand average, but wheels of the same design and manufacture are often found to vary quite as widely as shown in this table.

It is obvious that the radial load must be measured as the load acting between the axle and the tire contact with the ground, and it should be measured in pounds of load. The side thrust should be measured as the load at the neutral axis of the tire parallel to the axle, in pounds; the torsional stress as the inch-pounds of resistance or as a pound load, again at the tire neutral axis acting in the wheel plane; likewise the pivotal resistance, as inch-pounds or a pound load at the tire neutral axis, acting in a plane perpendicular to a theoretically radial spoke.

All of these resistance values should be, in static testing, those up to the elastic limit (100 per cent E. L.), as disclosed by load-deflection instrument curves, or by a series of intermittent readings. Breakdown loads are also well to record.

As a practical visualization of these relationships Table 1 is given, representing products manufactured by several firms in the years just past. It evaluates the variations of size and weight which have existed. We record them on the basis of resistance in pounds per pound weight of wheel using the elastic limit for the radial load as the comparative

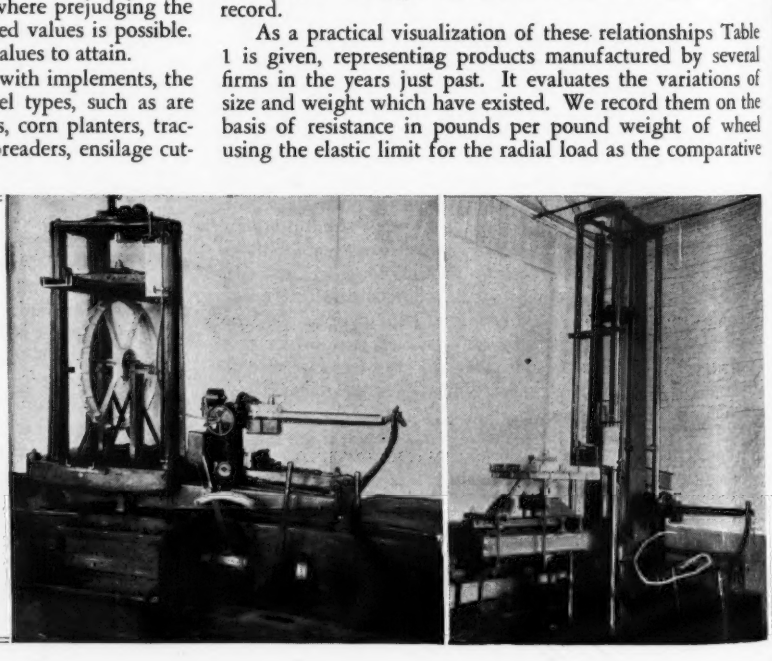
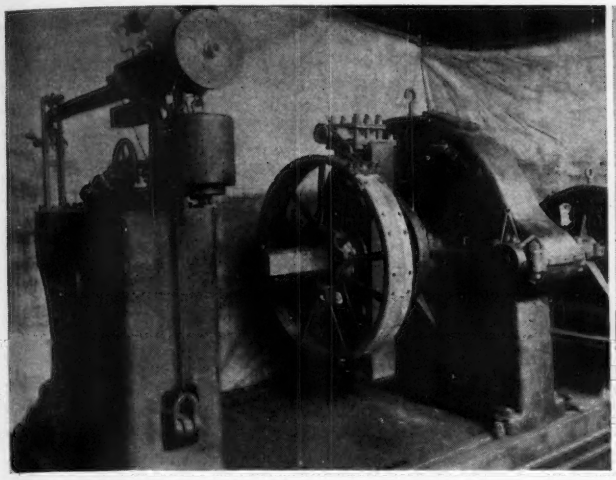


Fig. 1 A 50,000-lb Rhiele standard testing machine as used for static tests under radial load

Fig. 2 Rhiele high-column testing machine with fixtures for sidethrust testing



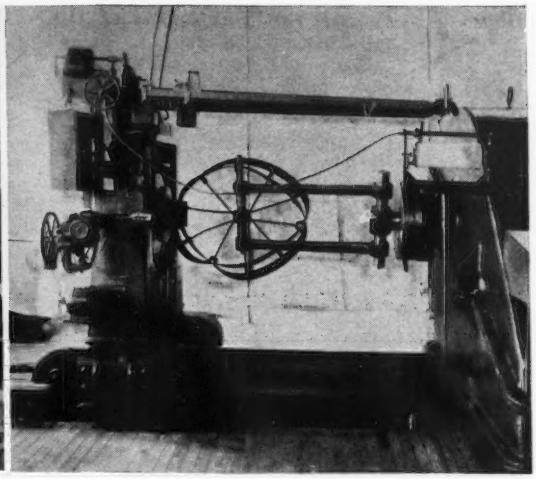


Fig. 3 (Left) Foote Brothers torsional testing machine, 1,000,000 in-lb capacity, set up for static torsion test
Fig. 4 (Right) Rhiele torsion testing machine, 300,000 in-lb capacity, as used in pivotal tests

resistance value, calling it 100 per cent basic and stating in percentage thereof the values of the others as the elastic limits of their respective tests.

The wide range of objectives back of the different type wheels, and the variations of diameter, shown in Table 1, of course do not fairly permit direct comparisons wheel to wheel, but nevertheless the table is of value in its emphasis of what exists. Also, owing to the indicated variations which exist in wheel requirements, it is shown that a pound of wheel material can be made to do magnificent work, or that skimping on material reduces markedly the attainable resistance value per pound of wheel. Scan the table with respect to hub diameters and the load-carrying capacity. If we could scan this table with respect to prevailing designs, large hub diameters with respect to wheel diameters and large load-carrying would be found to be prominently related. Those familiar with current designs will see this readily, and those less informed can refer to types in catalogs of the larger manufacturers and note this feature. A subsequent paper on hub and wheel design will cover this specifically.

The table presents a basis for considerable thought, study, and reflection as to the influence of design factors. Maybe the variations from the averages are definitely desirable, perhaps some construction factor has influenced the case, or it may be lack of balance due to arbitrary design. The forthcoming paper on wheel design will bring thorough attention to this problem.

Static Wheel Testing Equipment[4]

Much of standard testing equipment suitable for tension, compression, bend, shear and torsion tests can be made adaptable to wheel testing. Some of these adaptations are shown in the accompanying illustrations. A bit of ingenuity in the use of fixtures added thereto gives us reliable and inexpensive apparatus with which engineering data of great value is obtainable.

Fig. 1 shows a standard testing machine and the use of a double A-frame stand to hold the wheel and axle during test. This serves the purpose for static vertical loads, and needs only to be stiff enough to prevent deflections which would influence the records. One series of data should be taken relating to readings "on spoke" and one mid-arch "between spokes." Since an ideal wheel in action should show perfect concentricity, a practical wheel under load should show very little deviation therefrom; therefore the data taken on-spoke and between-spoke should be equal, within practical tolerances, unless material such as cast iron be used for weight purposes or other good reasons.

The contacting block in the testing machine should be such as will give reasonable contact area between pressure head and tire, say, 2½ in by the tire width.

Fig. 2 shows the case of sidethrust tests. Here, use is made of a cross beam resting on a pivot on one side and on the tire neutral axis at the other, equi-distant front and rear from the testing machine center. This set-up gives us actual record reading of double the test load and half the deflections.

Care should be taken in selecting as long a beam as is conveniently permissible and in its setting at start and finish so that the mean distortion deflection will occur when the beam is approximately level. This setting will not introduce radial loads or other strains of great enough moment to be misleading in the results.

Distortion of the wheel elements should be read at intervals between points on the wheel and corresponding points plumbed vertically below on the floor or other rigid, undistorted plane area. The differences between the zero readings before the start and at selected intervals record the actual distortion, which is to be plotted against the half load. Ratios other than 2:1 can be used if desirable.

Rigidity of the axle and A-frame is very important, and care must be taken to see that the axle be only a snug fit in the hub. An expansion-type arbor bushing between axle and hub bore aids in avoiding unnatural hub strains or distortion, present with ill-fitting assembly.

The test records should include one series over a spoke in tension and one over a spoke in compression, assuming spoke stagger exists. Readings or records are necessary up to the point where the automatic instrument record, or the plotting of data, indicates the elastic limit has been reached. Deflection data of the several spokes in the vicinity, besides the central spoke, give interesting information, for they have their typical bends and torsion, which latter is maximum at the right-angle point.

Fig. 3 illustrates the adaptation of a million inch-pound torsion testing machine so that it will operate on a heavy

[4]Equipment illustrated is that in research laboratories of the International Harvester Company, McCormick Works, Deering Works, Tractor Works, and 81st Street (Chicago) Works, and is here published by special permission.

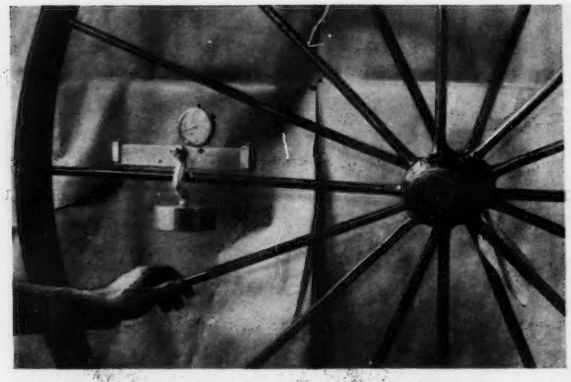


Fig. 5 Berry strain gauge, used to measure strains from either internal or applied stresses

tractor wheel. The test machine head has been run back to the left to reveal the set-up. Freedom of the tire to distort radially or sidewise under heavy strain is provided by the linkages to the rigid post head. Readings of angular distortion around the axle, and sidewise deflections as well, are again measured from fixed points or surfaces, and interpreted into values at the tire neutral axis.

Fig. 4 illustrates the pivotal test, which records the ability of a wheel to resist the stresses of boring action into the ground, as occurs in turning away sharply from the forward path or turning around at field ends. All such strains are particularly active when heavily lugged wide tires are used, as they tend to anchor the wheel to the ground. The measurements should be those of inch-pounds of load and degrees of angular distortion, up to the elastic limit. The reference radius is that of the tire neutral axis; hence, interpolation is necessary in case the set-up does not so record them.

Hysteresis curves are also advocated for study of a wheel's elasticity and recovery.

Strain Gauge Tests

Fig. 5 illustrates the determination of internal stress in the several wheel elements. These are ordinarily very elusive. It has been customary to gauge this condition as established during manufacture by taking a sample wheel, and cutting a spoke with a hack saw to note whether the cut ends separate or close the cut. Such rough gauging of tension or compression is informative for any given unloaded wheel, but is not a good measure of the stress in engineering terms. There is great chance for error, as has been repeatedly disclosed since using the modern strain gauge, especially because very often wide differences in stress were found among the several spokes of a single wheel. The strain gauge can be read accurately to one-half of a ten-thousandth of an inch, and readings can be made in statically loaded as well as unloaded wheels.

A wheel for check-up is selected and each spoke, or a selected number, are prick-punched to gauge, drilled with a small drill 8 in apart as indicated, and the values measured as shown in Fig. 5. Upon cutting one or more spokes outside these marks and remeasuring we secure a set of accurate data. Thus any variation in the product can be checked completely, whereas the older method gives the condition only of one spoke. If the process of manufacture permits, a few spokes previously drilled may be inserted in the line and after fabrication remeasured, thus saving the sample wheels from destruction.

Stress in tires may also be determined similarly. The change in stress during the progress of a life record of a wheel can also be followed. In case of wheels where the spoke-to-tire connection is made in a flat area, so that buckling in and out causes a weakening, the strain gauge will record it well ahead of the visual cracks.

Dynamic Testing

Rolling-load testing develops the important factor of fatigue resistance value. For comparative reasons it is necessary to establish a standardized footing and, as was shown in the previous paper, the tire-arch strain is greatest when the wheel operates on line contact, i.e., against a rigid surface. A base footing of maple wood blocks, impregnated by boiling in linseed oil, seems to fit the requirements of hard resilience.

Since in rolling-load operations in the field we often utilize skid rings or lugs, or have spokes protrude for various purposes, and these devices make rolling load testing difficult in some cases, and as the frame of the wheel must be substantial without any possible strengthening by lugs or rings, it seems sensible to check and test such wheels less lugs. The tire, however, must be ready to receive them, leaving the problem of their influence to controlled field tests, or where of moment to special laboratory set-ups to test the wheels with these attachments in place.

Wheels subject to travel over irregular surfaces, where the loads carried are seldom supplied with load easement springs, as is the case in the implement type wheels, make

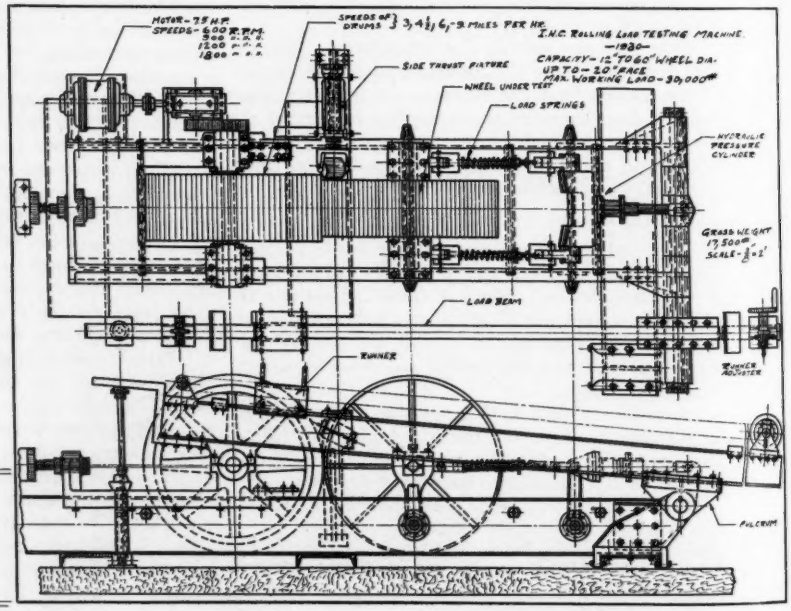
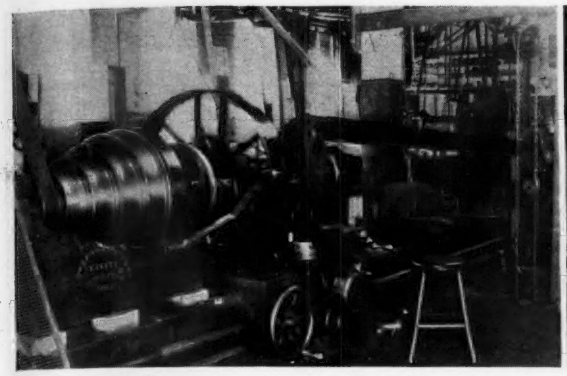


Fig. 6 International Harvester Company rolling-load testing machine, including provision for determining inertia impact stresses



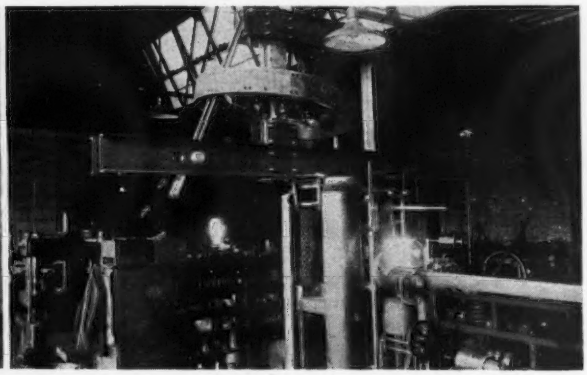


Fig. 7 (Left) A standard heavy lathe with fixtures for rolling-load, sidethrust testing

Fig. 8 (Right) Olson tension and compression testing machine, 200,000 lb capacity, with fixture for sidethrust testing of heavy tractor wheels

this feature involving inertia one necessary to be taken into account, when devising testing equipment. The test must simulate the field irregularities, and must be adjustable within the range of usual action.

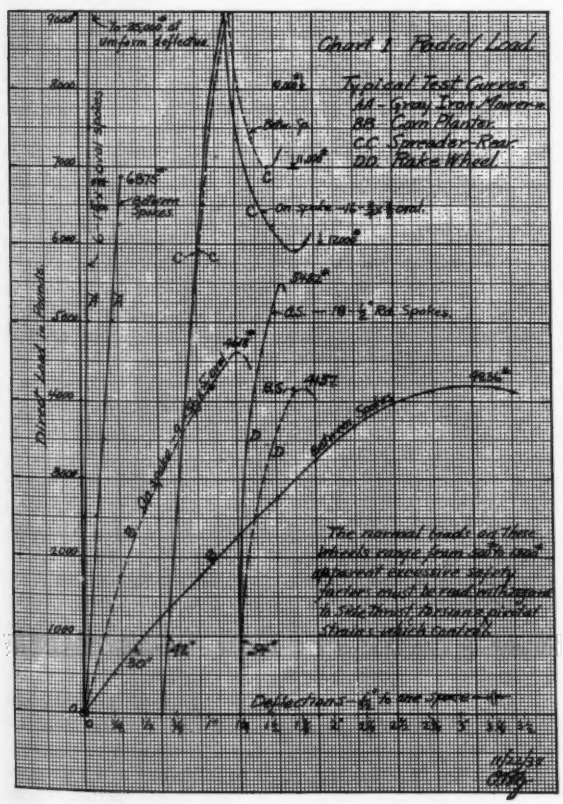
The International Harvester Company's specially designed rolling-load testing machine, illustrated in Fig. 6, shows how this feature is incorporated.

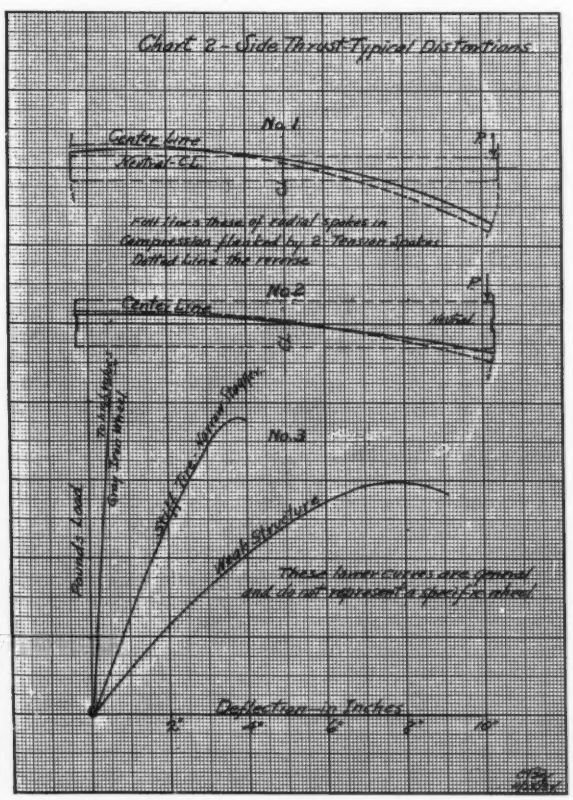
Fig. 7 illustrates what can be done to readapt shop equipment to a purposeful test use. The large lathe became a very serviceable test machine at little expense. By blocking up the head and tail stock, and by designing a roller and lever fixture to the heavy tool post and cross feed, a strong device for test resulted. The short arm of a beam lever carries the roller while the long arm can be calibrated for test weights to suit various wheels. Even heavy tractor wheels under sidethrust can be tested. The tail stock bearing, when used, should be provided with a special roller bearing where heavy tests are under way.

By turning the beam head at right angles to the line of the lathe centers, and replacing the long beam with a short arm, small wheels can be tested for radial loads as well.

A boring mill was also readily revamped along the same line. One such was used for testing medium and small wheels at each of two works.

Fig. 8 illustrates a set-up in a regular 200,000-lb tension and compression testing machine. The super structure designed for sidethrust tests of heavy tractor wheels is a balanced design clamped to the head of this machine and per-



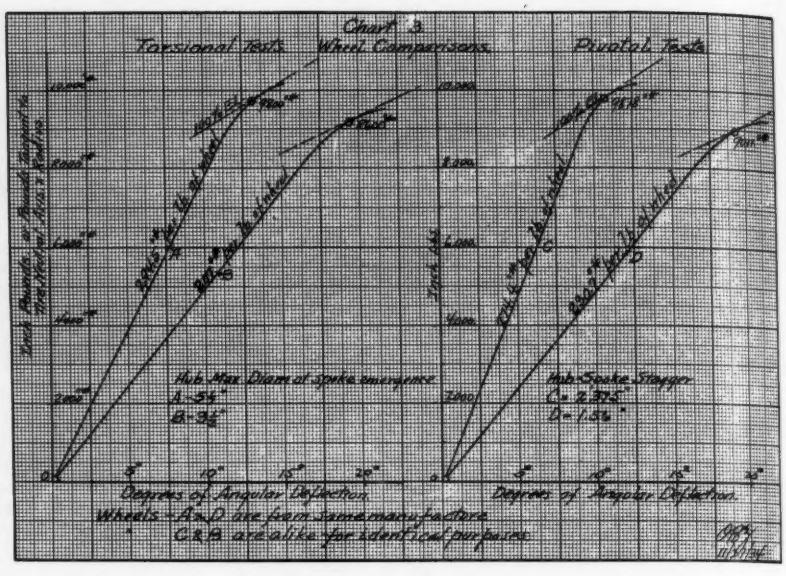


mits the special hook device to reach up through the head hole to the tire rim, and pull down vertically with measured force. The excess strength of fixture parts is emphasized, so that only minor deflections of that device will add themselves to the real wheel deflection.

TEST RECORDS

With these test machines and fixtures in mind it is now possible to review some typical data which visualize a wheel's resistance to the various major stresses.

Chart 1 is concerned with radial loads, and we have general comparisons of a mower wheel (A), corn planter (B), spreader (C), and a rake wheel (D). The marked stiffness of the gray iron mower wheel (A) is outstanding, and the large difference in relative strength of tire arch and spoke of 5:1 is to be noted. However, we recognize that strength alone is not the entire consideration here, since weight for traction is important when this type of wheel is used.



In contrast, the planter wheel shows exceedingly great elastic properties and low resistance. This original wheel had nine spokes, then in a desire to improve the spoke and tire-arch relationships, was made with 10 spokes, which brought the two new curves closer together than shown here. Curve B between-spokes also indicates a tendency to vacillating resistance in its deviation from a smooth curve, such deviation being due in some cases to a slip of a spoke in a punched hole, the pop-off of a spoke head, or shear of a rivet.

Curve C indicates good balance well up the line to the elastic limit. Curve D shows how a drill wheel reacts to test. Special attention is called to the high factors of safety in all of these wheels with respect to the normal load carried.

A generalization from these composite curves emphasizes the fact that most wheels break down from sidethrust and pivotal stresses rather than those of radial load or torsion.

Chart 2 gives some ideas of average sidethrust distortions. No. 1 (therein) is that of a cultivator wheel. This, a profile, shows clearly the location of maximum distortion, and also that the tire carries the load to the opposite side of the wheel, lifting the tire and the spoke ends above the neutral line. The amount of this lift is a function of the tire section, the number of spokes and spoke stiffness with respect to the load.

The two curves shown in No. 1 (of Chart 2) tell us an important fact, namely, that, generally speaking, the deflection of the tire shows the wheel weaker to sidethrust stress when the radial spoke under direct stress is in a tension position, rather than when it is in compression. The two adjacent spokes carry much of the load, as they are in the most active stress zone. The full lines shown in the diagram are those of the compression spoke, supported by two tension positions.

Bear in mind also, however, that the factor of stress in the spokes over and above the neutral set-up, and the number of spokes, have important influence as well. The technical discussion along this line in a future paper covering torsion, sidethrust, and pivotal stresses will disclose much of interest.

Chart 3 covers typical torsional and pivotal distortion to load of a representative wheel of two makes, in which the two designs show different emphasis, one relatively the stronger in torsion and relatively weaker in pivotal resistance; the other the reverse. The influence of hub diameter and spoke stagger are shown. Both wheels were of like diameter, spoke arrangement, and size, but there was still the variable factor of spoke tension which had higher influence in the wheel with larger hub and narrow stagger, as compared to the one with small hub and wide stagger.

Chart 4 gives the types of rolling-load test charts when a constant load or some multiple of normal load is applied over a period of hours, up to collapse. There is also an example of the increment load relationships superimposed, though this does not involve any cross-relationship.

This increment load test is considered excellent to show, in a reasonably brief time what maximum load a wheel will carry. Upon this data can be based the more detailed study of continuous load tests. These continuous load tests are very important to develop. There is also shown a set of lines giving relationships between spoke stress and spoke openings. The persistence under load of a highly jointed structure such as the wheel is exceedingly important, as breakdowns occur most commonly at these joints or nearby; also in welds.

CONCLUSION

It must be apparent from the foregoing that there is a wide extent of interests, many or all of which are justified in measures to develop equipment which, if coordinated through this society, can provide our field with engineering data of great value to all, in dealing with related wheels. The future papers anticipated will disclose further the technical factors, and wheel design will then follow far more logically, with better balance and better resistance values, than the thousands of years heretofore have provided by empirical methods.

It must be frankly stated that, for a considerable time after tests were started, the full import of the influence of impressed internal stresses, such as tension or compression, and the adverse effects of high values of either upon a wheel's resistance values, did not come forth. Wheels

made by customary processes gave erratic results. In fact, in some cases compression wheels out-ranked tension wheels, but this proved later to be the result of relative degree.

As soon as this stress factor was put under control, and comparisons were made without that stress as a wild variable, progress was made and high resistance values per pound of wheel came forth. This, along with structural balance, brought order out of apparent chaos, and the resulting consistent data obtained were splendidly assuring of fine engineering progress in wheel construction. Wheel manufacturing equipment, therefore, must be so made that it will permit this tension factor to be appropriately controlled.

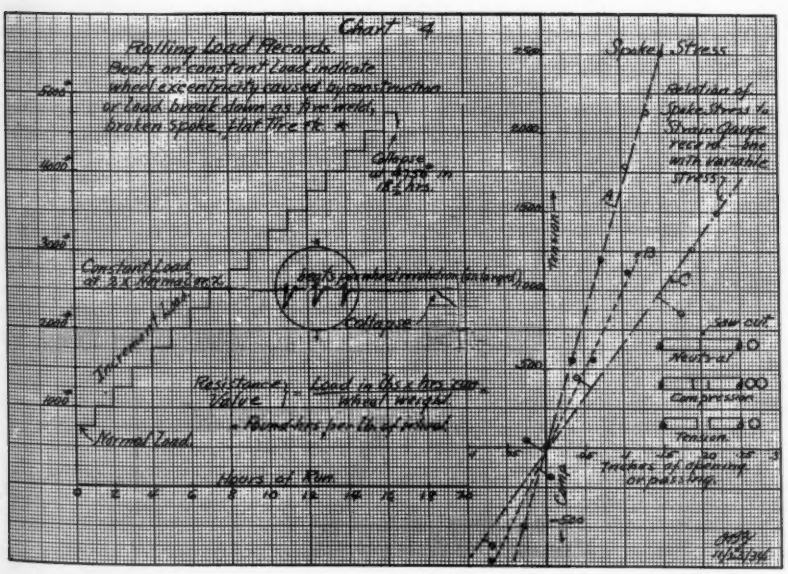
(AUTHOR'S NOTE: This section on testing methods is an appropriate point to recognize those who provided the means for carrying out the intensive study of the implement wheel problem, and those who participated actively in the development. No two firms in the world have had as many wheel problems within their experience as have the International Harvester Company and French & Hecht—the first with its world-wide activities, its variety of product, the variables of size, load, and power, and the latter with its supply of all manner of wheel units.

It is now apparent that it was good judgment of the management of the former company to attack this resistant problem with a view to standardization in its many phases if practicable, such standardization seemed frankly hopeless for years. At least four efforts were previously made towards a solution. Involved were the factors of repairs, design, equipment, manufacturing methods, sales, materials, advertising, economics, etc. The wheel committee of the International Harvester Co. worked on this problem for over four years, accompanied by the destructive testing of many more than a thousand wheels, commercial and specially built. While the work was not by any means completed, the skeleton of positive information was sufficient for a manufacturing program to be outlined in accordance thereto. It is certain that the results attained will filter into commercial use as fast as economic factors will permit.

It is natural also that many men entered into the problem, adding their special knowledge or experience toward the common end, so that practically every engineer who had worked on wheels in the Harvester Company came into the problem at one time or another. The following should receive special mention as contributing a worth-while measure of constructive ideas and effort: From the I.H.C. management—Cyrus McCormick Jr., E. A. Johnston, C. R. McDonald, A. C. Lindgren; from the engineers—B. R. Benjamin, H. D. MacDonald, W. S. Graham, C. W. Robinson, R. D. Mancinelli, G. McNamera; from manufacturing—J. R. Allen, E. R. Graves; C. Hartman, G. A. Johnson, F. H. Amos, H. Slivinski; from the testing laboratories and metalurgy—W. D. McMillan, F. S. Badger, R. J. Murphy, J. Polivka, J. Peternel, R. Mijka; also R. D. Acton, patent dept.; W. A. Baylis, repair records; H. A. Homan, sales angles; T. Soma, foreign sales data and conditions.

French & Hecht Inc. contributed through W. F. Heesch, E. E. Einfeldt and J. Plain by making up wheels for test and to specifications.

Taylor Winfield Corporation advised extensively on electric welding, through Mr. Clyde Bassler and Mr. Clark. They finished knockdown wheels for test to establish many points regarding resistance value of electrically welded wheels.



Discussion by E. E. Einfeldt[5]

THE STRUGGLE in the wheel industry has always been to obtain minimum weight with the greatest amount of strength. We are continually making laboratory tests on wheels in order to attain the best results. Implement wheels range from 12 to 80 in in diameter and from 5 to 900 lb in weight. There are over 6,000 different types of implement wheels. Some are designed to carry maximum vertical loads, others for maximum side strain, others for torsional loads, etc. Again, some require heavy tire sections to resist wear. These facts must be considered in construing any test based on average load per pound of wheel. It would seem proper when testing a large variety of wheels to classify them first according to the service they are to perform. The average of each group can then be given consideration as suggested by Colonel Zimmerman.

Certain formulas are followed to determine tire sections, spoke stagger, etc., but we must never lose track of our practical experience. Many different tire shapes are necessary to meet operating requirements, namely, convex, concave, flanged, grooved, and others. It is always desirable to select a shape of tire which gives maximum strength with minimum amount of material, although there are times when other shapes must be substituted to meet working conditions and certain soils.

After the tire selection, it is necessary to design a hub in order to obtain the proper stagger with relation to the diameter of the wheel; also to select the material to be used in the hub, this depending on the type of machine on which the wheel will be used, and whether it is to be a removable box or solid hub. Then comes the very important matter of securing the spokes in the hub as well as in the tire. Many wheels fail because of poor spoke fastenings.

Very important also is the right amount of tension in the spokes. This varies in different wheels. It has been our practice and our aim to produce wheels with uniform tension and exhaustive tests have been made to determine the proper amount of tension in different types of wheels. It has been shown that two wheels identically the same in specification show a vast difference in testing because of different tension. The wheel properly tensioned will outtest a neutral wheel or one excessively tensioned or with uneven tension.

Our concern made static load tests as far back as 30 years ago. We obtain a great deal more information by making wheel comparisons with dynamic tests on a machine on which we are able to apply from one to 7000 lb of vertical load and from 10 to 600 lb side load

[5]Chief engineer, French and Hecht, Inc.

traveling at variable speeds over a roll. In different types of dynamic tests we run the wheel for a longer time, which will bring out defects that we would not be able to ascertain in a fast break-down test. After the wheel has been operating a certain number of hours the loads are increased until breakage develops.

It is also necessary to give some consideration to the chemical properties of the steel to be used. Rolling mills require a variable of 0.10 in carbon which is sufficient to affect the test.

Tractor wheels involve a somewhat different line of testing than implement wheels. In one type of test, the wheel is mounted on the axle, the axle is mounted on two channel arms and the wheel is driven by a motor. Lugs are placed on the rim and the wheel is revolved against a hard chilled block. This is known as a fast break-down test, but a fast break-down test does not always tell the story.

Another tractor wheel test is a torsional strain test, consisting of loading and unloading, similar to starting and stopping the tractor. This test is measured by pounds and number of strokes and is set up in excess of the tractor load. The wheel is vibrated until crystallization occurs and the spokes break. After the spoke breakage occurs, the spokes should still remain tight in the hub and in the tire.

Another test for tractor wheels, such as the general-purpose tractor wheel which is subject to considerable side-thrust by the use of short-turning brakes which is extremely hard on narrow rim wheels and must be compensated for in the stagger, consists of a side load revolving test which can be done by several methods. One is to have a roller run against the edge of the tire; in another a triangle structure extends a certain distance from the wheel and carries weight.

The two items mentioned above must be considered in tractor wheel design, torsional and side strain as well as proper fastenings and tension. Vertical load carrying capacity of tractor wheels is not so important as torsional and side strain.

Referring to Chart 1 of Colonel Zimmerman's paper, we see a comparison of vertical load tests against deflection of a heavy cast-iron mower wheel. It is stated that the strength alone is not the entire consideration. The important item is to provide weight for traction. The weight of a cast mower wheel is from 90 to 110 lb. A steel-spoke mower wheel with proper shape of steel tire will deliver sufficient traction with about one-half the weight of the cast-iron wheel.

In conclusion I wish to suggest that the great variety of wheels for the same purpose is not a reflection on the wheel producer. Often the specification and design of the implement are such as to make it impossible to use wheels of lightest weight and approved design. Frequently the implement designer does not give consideration to the wheel until after the implement is completed.

Discussion by Theo Brown[6]

IN DISCUSSING Colonel Zimmerman's treatise, I will confine myself to the problem of rolling tests. As has been pointed out, implement wheels are subject to (1) radial load, (2) sidethrust, (3) torsion, and (4) pivot stresses. In some types of wheels the radial load is the only factor to be considered, while in others two or more of the above mentioned stresses are an important consideration.

As an implement wheel should stand up almost indefinitely under normal operating conditions, it is impractical to make tests under normal conditions; and it goes without saying that rolling tests are necessary, for it is folly to think of placing a newly designed wheel in production without knowing beforehand that it has an assurance of standing up in actual use. It thus becomes necessary to make accelerated tests which can be completed in a reasonable length of time, with nominal cost and which can be relied upon to give as accurate a picture as possible of the stresses to which the wheel is subject and how well the wheel withstands them; also, to get comparative results with a wheel which experience has demonstrated to be satisfactory.

First, let us consider a rolling test for radial load stresses. To accelerate the test there are three elements which can be changed to shorten the time for testing:

1 Increased speed
2 Increased load
3 The characteristics of the surface on which the wheel rolls.

It is very desirable to establish a procedure for such tests, and so the proper combination of the three variables mentioned above must be determined by conducting a number of preliminary tests, using wheels that are known to be satisfactory as a basis for the decision. We have felt that the greatest variable with which we have to contend is that of the character of the surface on which the wheel rolls. The condition of the soil or sod which might be used for testing purposes is never uniform, and so we have felt it necessary to provide a surface that does not vary. A concrete track seems to be satisfactory. This makes it possible to run tests regardless of weather conditions.

On a surface as hard as concrete, we have found that tests show more uniformity when the speed is fixed at not much greater than normal. Under these conditions, a 50 per cent overload has proved to work out best. As an interesting sidelight, in one test a 100 per cent overload ran but one-sixth of the time of the 50 per cent overload at the same speed before failure occurred.

For these tests, a two-wheeled cart with weight boxes is used, pulled behind a truck traveling at a fixed speed; usually a wheel of new design being run with a wheel that has been proven satisfactory. The track on which the tests are made is a circular one, and the direction of travel changed after a given number of rounds so as to equalize any variation of road conditions. The condition of the wheels is noted and checked carefully after each round when signs of failure become apparent.

Characteristic failures in these tests are flattening of tire between spokes and bending of adjacent spokes in plane of spokes, cracking of flanged tires and breaking of spokes at the outer end.

While this test is particularly hard on the tires, yet it has proved out in practice to be reliable, and a wheel standing up under it for a predetermined distance will be reasonably sure to prove satisfactory in actual use.

In establishing a standard test procedure certain information is necessary. The normal load the wheel must carry and the normal speed at which it will travel are essential before applying any formula.

The straight radial load is the simplest test and probably the best one for which to start a standard procedure. The tests for thrust, torsion, etc., are much more difficult, for the stresses, as Colonel Zimmerman states, are combined and shifted over a wide variation and may well be left for future consideration.

[6]Manager, experimental department, Deere and Company.

The Battle for Adequate Farm Buildings[1]

By R. C. Miller[2]

MILITARY generals usually claim that to locate and know the strength of the enemy is a battle half won. The scientist says about the same thing when he holds that a problem well stated is half solved. This seems to indicate that when some situation is to be remedied, it is wise to first find out just what and where is the problem. The battle that must be won for farm buildings is how to obtain adequate repairs and replacements. The first logical step should be to locate and know the strength of things we must overcome.

First, we might examine some of the solutions that have been offered and see how they work. By a process of elimination we may arrive at the place where we know who are the allies and enemies and where we must do the fighting. The serious farm building replacement and repair problem seems to have a rather simple solution, if the universal answer given to the question is any real answer. "Give the farmer a better price," or sometimes stated in the form, "Give the farmer a profit, and the buildings will be taken care of." There is no doubt but that more farm income would make the building problem easier to solve, and that for some farmers it would be the solution for it does require money or capital to purchase some of the necessary materials and skilled labor.

There are several good reasons, however, why a better farm price does not solve the building problem. One reason is that the buildings were neglected almost as much during the period of high farm prices, during and for ten years following the World War, as they have been during the past four years of depression prices. The results of the federal rural housing survey, conducted last winter (1933-34), indicated that most of the repairs and improvements needed are of longer standing than of the past few years. If, then, the high farm prices, during and for the ten years following the World War did not correct the building repair and replacement condition, is there any reason to hope that it would be the solution now?

A second reason why the better-farm-price reason is likely not to be a solution of the farm building problem is that we have no assurance that farm prices will be appreciably better, regardless of the fact that we all want better prices. It seems reasonable to assume that we cannot expect as high prices in the next 15 years as we have had in the past 15 years. If we can learn from the past, the lesson certainly is that prices move in cycles, and that over a period of years they average about the same. Regardless of what the farm price may be, we need good buildings. Usually the poorer the prices, the greater is the need for better buildings. When the farm prices are low, a margin of profit can be attained only by efficient production which usually means better structures. Also, low prices mean less money available for heating the home and paying the doctor. At such times a modern well-heated and insulated house is the cheaper way.

A third reason why better farm prices is not a solution of the building problem is that such an answer is likely to be an *excuse* for not having done anything or doing anything now rather than a method of solving the problem. There are, no doubt, many problems in our lives that we can solve by simply giving a good excuse, but excuses, even though they are real good ones, as it is in this case where we all know that farm prices and income are extremely low, will not build or repair structures.

If, then, we are convinced that better farm prices is not a dependable ally, but is possibly even an enemy in so far as it is an excuse that keeps us from action, are we not ready to abandon the false hope of financing structures through better prices and to conduct a campaign that will finance adequate structures in spite of the price conditions?

With the price excuse somewhat tied, so it is harmless for the time being and placed in the background, let us give a little thought to what is required to do building repair and replacement. It is evident that it requires materials with or from which to build. Many of these materials are available on the farm with no cash cost. There is the ground in which we can dig such structures as storage cellars and trench silos where often no other material is used.

Many farms have woodlots where all kinds of timber, from framing to finish lumber of the best quality, can be obtained at no cash cost, or at least a very low cost. Lumber that often costs $75.00 per thousand board feet in a lumber yard, can be obtained from the farm at a cash cost of $7.50 for the sawing. Sometimes even the sawing may be done on shares so there is no cash outlay. In many cases the logs may be used in the same manner as the pioneers used them and as our wealthy folks like to construct their country homes. The log building is by no means the poorest type of structure we can have. It has many merits, such as sturdiness, long life and insulation, that our flimsy frame structures often do not have.

Many farms have stone and rock that are available for the labor of gathering them. There is no more permanent and better appearing material than the rock native to a locality. There are also clays and shales from which the highest class of building brick and tile can be made. Many of our present brick farm houses are made of brick that was dug, molded, and dried or burned right on the farm where it was used. There is a possibility that rammed earth may be used as a building material. Almost every farm has some of these low-cost materials available.

Labor is an item which in barns usually amounts to about 25 per cent and in houses to 50 per cent of the cost of the structure. Much of the labor necessary to do building repair and replacement is not so highly skilled but that some farmer can do it. It may mean an exchange of labor but not of cash.

Possibly the most difficult financing problem in modern construction is the hardware and what we term the modern conveniences, such as electric power and equipment, bathrooms, furnaces, and kitchen equipment. Even much of that can be installed at a much lower cost on the farm than in the city. For example, the cost of obtaining water piped into a city home and the cost of the city sewer to the city home is usually considerably more than the cost of obtaining and installing a water supply with the necessary sewage disposal system on a farm.

Those who say that building repair and replacement cannot be carried out with low farm prices, usually do not take the foregoing factors into account and do not observe

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[1]Presented at a meeting of the Farm Structures Division of the American Society of Agricultural Engineers, at Chicago, December 3 and 4, 1934.

[2]Professor of agricultural engineering, Ohio State University. Mem. ASAE.

that there is usually someone in every community who is doing it right now.

But this discussion has not yet pointed the way to obtaining even the little cash that is necessary, and especially so since better prices have been ruled a poor excuse. There seems to be a pretty good path although it is not easy to follow. It is the means used by nearly all the farmers who have done and are today repairing or replacing old structures. The method is simple and is not new. These farmers obtain the money from the only place it can possibly come—unless it comes as an outright gift—and that is from the meager farm income. The situation is possibly well described by a farmer who is at this time remodeling his barns. He said, "There is not much income, and there are many things we need—especially would the boy like to have a better car—but we must have barns for the cattle and feed, so we do this first." Well, that is what our forefathers did. They tended to getting shelter first and then came the tending of crops and the hunting for food and clothing materials.

It is necessary that we study how our meager income is spent to see where more may be used for buildings. Following are figures from a summary of cost accounts kept in 1932 (a poor year) by 100 farmers in Knox County, Ohio, in cooperation with the farm management department of Ohio State University; these farms averaged 150 acres in size with 70 acres in crops:

Capital Investment per Farm

Land	$5,219.00
Buildings and fences	3,744.00
Livestock	1,598.00
Feed, grain, and hay	872.00
Machinery and tools	1,300.00
Total Capital	$12,733.00
Cash receipts	$1,470.00
Cash expenses	659.00
Cash Balance	$ 811.00

The $811 cash balance was, of course, insufficient to take care of an inventory loss on crops and livestock of $471.00, plus an interest charge of 4 per cent on the investment totaling $434.00. So there of course was nothing left for buildings. Let us look for a moment at the items of cash expenditure that amounted to $659. In the item of cash overhead expense was one item of $8, or about one-half of one per cent, used to repair the essential buildings and fences. These same fences and buildings no doubt would cost at least $7,500 to replace, judging by their present value which was $3,744. These buildings, whose depreciation figured as low as one per cent per year, which amounts to $75, received only $8 of the total cash income. The expenditure for insurance was more than twice as great, $20. If a fire should destroy our farm buildings, we likely would have considerable insurance with which to finance the rebuilding. But, if the buildings just wear out through years of service, we still finally lose the building, but we usually do not have the money for replacing the structure.

That we are insured for calamities but not prepared for living, is a quite truthful statement of the situation. In the past few decades we have had some building fire and tornado loss replacement financed by insurance. There has been very little replacement of buildings that have just worn out. It seems quite evident that, if our farm buildings are to be repaired or replaced, it can be done only if we have a fire or tornado loss. Fortunately or maybe rather unfortunately, the fire and tornado losses affect only a small per cent of the farm buildings in Ohio. The big problem is how to repair or replace the ninety-nine per cent of buildings that are not destroyed by fire or wind. The one possible and logical answer is that we must take our building costs out of our gross cash income. The buildings really are part of the essential operating costs and thus deserve being cared for. In order to give more of the gross cash receipts to buildings, some other expenditures must be cut, for example, interest, an item of $434; taxes, $140; feed bought, $108; livestock bought, $32; etc. That is a problem deserving of our attention, but there is no space for that now.

The building situation may also be improved by cheaper and longer loans. The federal home loans seem to be a reality now, but all that is another story, and, at best, a story dependent for its success upon paying for the buildings some time out of the farm income. It does offer an opportunity to pay on the installment plan which seems to be the general method of financing luxuries. This should justify its use in financing essentials such as building repair and improvement.

I hope this discussion has helped to locate the enemy of adequate farm structures. We know something about the strength of excuses in keeping us inactive. We know a few things about what we can and may do to have better buildings. There is need no doubt to further locate the enemies to adequate structures and to find ways of waging a successful battle. It is evident that no quick and easy scheme will bring adequate structures. It will be a hard and long, in fact, almost a continuous battle. Our methods are simple, as pointed out, but the way is not easy. It will require a constant drive in education to teach the appreciation of services rendered by buildings to agriculture as an industry and mode of life. Right now it seems that the best help could come from those who are winning their battle for better buildings in face of the great odds as some are doing. Let us have their story as to how they are doing it. The fighting is still to be done.

Good Buildings Pay

IT IS FALSE ECONOMY to build poorly planned or cheaply constructed buildings, as they cause a serious financial loss through high depreciation, and the additional labor involved in using buildings not properly planned or located. This statement is well proven by a recent study made by the division of agricultural economics and the division of agricultural engineering of the University of Minnesota on forty representative farms to determine the farm operator's labor earnings. The data reveals convincing evidence that the twenty farms having the best buildings have returned to their owners the largest earnings for the labor expended. This is scientific proof that good buildings do pay. They not only pay for themselves, but also enable the operator to secure a larger return for his labor, to say nothing of the pleasure and satisfaction he enjoys while doing his work, a very important factor which is often overlooked. Good buildings are those well suited to the individual farm and the owner's circumstances. A good operator will work better and more efficiently with good buildings. If the buildings are poor, he usually makes them better or he gets another farm to operate.

Good farm homes are indicative of high standards of living. There is probably no other one thing that influences the people of a community for the better things of life so much as good homes.—WM. BOSS

Precooling Fresh Fruits in Refrigerator Cars

By F. C. Gaylord[1], K. I. Fawcett[1], and T. E. Hienton[2]

CONSUMERS prefer fresh fruits such as strawberries, peaches, and cantaloupes which are vine or tree-ripened. Common shipping practices of the past have not enabled the grower to market products of maximum quality. In an effort to aid growers in best meeting the demands of the discriminating consumer, the Purdue University Agricultural Experiment Station has conducted tests in the precooling of cantaloupes, peaches, and strawberries, and has followed these shipments through to destination.

Methods of precooling in use include placing fruit in cold storage rooms until cool prior to loading, and cooling the fruit in the car after loading prior to shipment. The latter method was chosen since the investment which would have been required in the first method appeared too great to be practical.

Results of work reported by the USDA Bureau of Plant Industry and the agricultural experiment stations of California and Illinois indicated that, by circulating air inside the refrigerator car, the rate of cooling was increased. In the Illinois work the natural movement of air currents was increased by blowing the air into the tops of the ice bunkers and out at the bottoms. In the other work mentioned the direction of the air currents was reversed so that the cold air was directed down on top of the lading instead of up through the bottom.

In cantaloupe shipments large losses occur through higher temperatures in the top third of the car, resulting in overripening of top layers of cantaloupes. To remedy this situation shippers have picked green cantaloupes with resultant loss in quality. The results secured in 1933 clearly indicated that by precooling the cars at shipping point, the temperatures can be lowered to the most desirable point and ripening processes almost completely stopped. By this means the melons may be picked at three-quarter or full slip with higher sugar content, immediately precooled, and reach the market firm and in good condition. The records show that by the use of the fans temperatures both in the top and bottom of the car may be lowered at small cost, so that the product at shipping point has been refrigerated as much as it would be at destination some two or three days later.

In the southern Indiana strawberry area, a large portion of the crop is graded to meet U.S. No. 1 requirements, packed in 24-qt ventilated crates and shipped in standard refrigerator and express cars to distant markets. The berries are usually picked at high temperatures and loaded directly into the refrigerator cars. Records showed temperatures from 80 to 95 deg F inside the fruit at loading time. Because of the slowness of cooling under standard refrigeration, berries often arrive at destination in poor condition. The 1934 records showed that by precooling in the cars at loading point, the temperatures inside the fruit could be lowered so that the fruit started to market at temperatures around 50 deg F or lower. These lower temperatures retard ripening processes and insure the berries arriving at distributing points in better condition.

[1]Department of horticulture, Purdue University Agricultural Experiment Station.

[2]Department of agricultural engineering, Purdue University Agricultural Experiment Station. Mem. ASAE.

In Kentucky during the 1933 season, some buyers paid $25.00 a car extra for precooled cars of strawberries. After the equipment is installed the power and labor cost of precooling a car of strawberries, cantaloupes, or peaches would be less than $2.00, under conditions as outlined in these investigations. To secure greatest benefits from precooling requires the grower and shipper to grow, grade, and pack a U.S. No. 1 or better product.

Precooling of peaches is more difficult, as the standard peach basket with paper pad on sides and top tends to insulate the peaches in the basket again rapid cooling. Results indicate that by some changes in the basket even more satisfactory results may be secured than is reported here. It is questionable whether or not precooling peaches will be of commercial importance. Rapid lowering of temperatures in cars would enable peach growers to pack somewhat riper product of higher quality, and through low temperatures partly control brown rot.

Tests were continued during 1934 to determine how rapidly cantaloupes, peaches, and strawberries could be precooled after they were loaded into refrigerator cars. A total of nineteen cars of cantaloupes, three cars of strawberries, and four cars of peaches were precooled during these tests, using three different fans. Results of these tests are listed in Table 1.

Fans. All the 12-in fans used were of the propeller type. Six 1200-rpm, 12-in fans were used, three at each end, in the first tests conducted in 1933. This number was increased to ten, with five at each end, during the same year, in an effort to increase the rapidity of cooling. They were mounted in a three-sided wood frame which was placed at the upper opening into the ice bunker. During 1934 ten fans of the same type but of higher speed, 1800 rpm, were employed on cars 13, 14, 15, 16, and 21. Disk type fans of 18-in diameter, one in each end of the car, were used on cars 17, 18, and 19 as well as on strawberries. These fans were loaned by a commercial company which furnishes precooling service to shippers through the southeastern and south central states. The 12-in fans were loaned by a manufacturer of electric ventilating equipment. The 12-in, 1200-rpm and 1800-rpm fans were rated at 750 and 980 cfm, respectively, while the 18-in fans were rated at 3,600 cfm.

Temperature Measuring Instruments. Temperatures were taken at ten points in the car by means of thermocouples and potentiometer. The temperatures were all taken at five points in one end of the car equidistant from the middle to the end of the car in the top and bottom center rows of crates or baskets. The ends of the thermocouples were inserted into the centers of the fruit being precooled. In the case of peaches the temperatures were taken as nearly as possible at the centers of the baskets.

Average temperatures listed in Table 1 were obtained by averaging the five readings for top or bottom of the lading. Temperatures were taken on cars enroute by shipping the thermocouples in the cars, bringing the ends through the doors and fastening them to the walkways on tops of the cars, where the potentiometer and switch could be attached.

Rate of Cooling. Tests were made on cars 1 and 2 with six fans blowing air into the tops of the ice bunkers to increase the natural air movements. Inspection of the results shows that cooling was faster in the bottoms of the

(Left) Five 12-in, 1200 rpm propeller type fans were installed in each end of the refrigerator car during tests on precooling peaches in Indiana by agricultural engineers of Purdue University. (Right) Temperatures were taken at ten points in precooled cars, on the tops of the cars, while they were enroute to destination by the use of thermocouples and potentiometer

loads than in the tops, as might be expected. The favorable effect on rate of cooling by use of salt on the ice is shown by comparing cars 1 and 2. A comparison of car 1 with cars 7 and 20, which were not precooled, shows that the entire lading of the precooled car cooled faster than those in the cars where fans were not used.

Fans, in all cars precooled other than 1 and 2, were installed so that the natural movements of the air in the car were reversed, that is, the cold air came out of the top bunker openings instead of the bottom openings. The effect of this reversal on the cooling of the lading is shown by a comparison of cars 3, 4, and 5 with car 1, or car 9 with car 2. The same result is shown, whether or not salt was used, that the top of the lading cooled much more rapidly than the bottom where the natural air movements had been reversed by the fans. This is desirable as records in Table 2 show that the bottom of the lading cools first while the top cools much more slowly when cars are shipped without precooling.

It may be noted from Table 2 that the average temperature of the cantaloupes on the top row was as low at time of shipment as it was 23 hr later while that in the check car did not reach that figure for more than 24 hr. It should be observed that final top temperatures of the cars of cantaloupes were nearly the same, indicating that an inspection at destination may not reveal the temperatures of the fruit while it was enroute.

Rate of Cooling as Affected by Fans Used. The effect

TABLE 1

Car	Date	Ice down bunkers at fan start, in	Fans		Salt	Temperatures						Cooling time
						Average start		Average final		Average drop		
			No.	Type		Top	Bottom	Top	Bottom	Top	Bottom	
CANTALOUPES												
1	7-27-'33	18	6	1200 rpm, 12 in		75.6	62.0	67.4	53.3	8.2	8.7	3 — 15
2	7-28-'33	12	6	1200 rpm, 12 in	200	81.2	70.6	70.4	58.0	10.8	12.6	3 — 30
3	7-30-'33	24	6	1200 rpm, 12 in		76.8	61.0	60.2	58.8	16.6	2.2	3 — 52
4	7-29-'33	12	6	1200 rpm, 12 in		82.8	69.2	70.2	67.7	12.6	1.5	3 — 00
5	7-31-'33	12	6	1200 rpm, 12 in		85.6	78.8	74.8	74.6	10.8	4 2	2 — 00
6	8- 1-'33	36	6	1200 rpm, 12 in	200	78.4	56.6	58.2	59.2	20.2	−2.6	5 — 00
7	8- 1-'33	12		None		86.4	73.6	85.6	67.4	0.8	6.2	2 — 00
8	8- 2-'33	12	6	1200 rpm, 12 in		75.4	69.0	66.0	68.4	9.4	0.6	1 — 53
9	8- 3-'33	12	6	1200 rpm, 12 in	200	80.0	69.8	65.0	67.0	15.0	2.8	2 — 57
10	8- 4-'33	12	10	1200 rpm, 12 in		75.4	64.6	57.4	61.4	18.0	3.2	3 — 05
11	8- 5-'33	18	10	1200 rpm, 12 in	200	76.4	68.8	55.8	64.8	20.6	4.0	4 — 00
12	7-23-'34	36	10	1200 rpm, 12 in	200	87.8	77.8	67.8	71.0	20.0	6.8	3 — 45
13	7-21-'34	24	10	1800 rpm, 12 in	200	89.4	77.4	75.8	72.4	13.6	5.0	1 — 30
14	7-22-'34	40	10	1800 rpm, 12 in	200	83.4	70.0	68.6	73.8	14.8	−3.8	4 — 00
15	7-24-'34	42	10	1800 rpm, 12 in	200	83.4	73.6	71.0	69.4	12.4	4.2	3 — 00
16	7-25-'34	42	10	1800 rpm, 12 in	100	85.0	54.6	66.4	63.8	18.6	−9.2	4 — 02
17	7-30-'34	18	2	1750 rpm, 18 in	200	83.4	72.6	62.0	70.2	21.4	2.4	3 — 00
18	8- 2-'34	26	2	1750 rpm, 18 in	200	79.4	74.5	53.0	60.0	26.4	14.5	5 — 30
19	8- 3-'34	38	2	1750 rpm, 18 in	100	74.6	68.0	56.4	61.2	18.2	7.2	5 — 00
20	8- 3-'34	38		None	100	79.2	72.2	82.4	67.8	−3.02	4.4	2 — 20
21	8- 6-'34	36	10	1800 rpm, 12 in	200	76.6	61.0	56.0	62.5	20.6	−1.5	4 — 00
STRAWBERRIES												
22	5-31-'34	Full	2	1750 rpm, 18 in	200	65.0	64.0	54.0	57.5	11.0	6.5	1 — 44
23	6- 2-'34	Full	2	1750 rpm, 18 in	200	62.6	58.4	50.0	50.6	12.6	7.8	2 — 56
24	6- 3-'34	Full	2	1750 rpm, 18 in	200	70.8	56.2	47.4	51.4	23.4	4.8	4 — 00
PEACHES												
25	8-15-'33	18	10	1200 rpm, 12 in	180	65.0	64.4	59.6	59.2	5.4	5.2	8 — 00
26	8-16-'33	Full	10	1200 rpm, 12 in	180	72.0	69.4	69.8	63.0	2.2	6.4	3 — 00
27	8-17-'33	Full		None	180	78.4	76.2	76.0	69.2	2.4	7.0	2 — 02
28	8-17-'33	Full	10	1200 rpm, 12 in	180	75.4	74.0	62.8	65.2	12.6	8.8	6 — 09
29	8-20-'33	12	10	1200 rpm, 12 in	180	67.4	61.2	59.6	55.6	7.8	5.6	4 — 00
30	8-20-'33	12	10	1200 rpm, 12 in	180	71.8	65.6	61.6	58.4	10.2	7.2	4 — 00

TABLE 2

	Precooled		Check		Precooled		Check
Car numbers	28		27		19		20
Material shipped		Peaches				Cantaloupes	
Salt used, lb	180		180		100		100
Time loaded	3:00 p.m.	(8/17)	8:35 p.m.		1:15 p.m.	(8/3)	5:15 p.m.
Time shipped	10:40 p.m.	(8/17)	10:40 p.m.		8:00 p.m.	(8/3)	8:00 p.m.
Average temperature at time of loading	Top 75.4		78.4		74.6		79.2
	Bot. 74.0		76.2		68.0		72.2
Average temperature at time of shipment	Top 62.8		76.0		56.4		82.4
	Bot. 65.2		69.2		61.2		67.8
Average temperature at 12 noon	Top 57.6		66.2	Average temperature at 6 a.m.	Top 58.8		71.8
	Bot. 52.8	(8/18)	52.0		Bot. 47.0	(8/4)	51.8
Average temperature at 8:40 a.m.	Top 54.2		57.8	Average temperature at 7 p.m.	Top 57.0		63.4
	Bot. 46.4	(8/19)	45.0		Bot. 42.2	(8/4)	47.6
				Average temperature at 10 a.m.	Top 52.0		52.8
					Bot. 39.0	(8/5)	42.6

of using ten 12-in, 1200-rpm fans instead of six is best shown by comparing the results of cars 4 and 10. These cars were precooled approximately the same length of time with similar amounts of ice in the bunkers and initial top temperatures were not widely different. Using six fans, temperature drops were 10.8 and 4.2 deg for top and bottom, respectively, while with ten fans similar results were 18.0 and 3.2 deg.

Cars 11 and 17 furnish some comparison between the use of ten 12-in, 1200-rpm fans and two 18-in fans since approximately the same amount of ice was available in each. After three hours operation of the fans there was an average temperature drop of 17.2 and 21.4 deg for the top and 1.0 and 2.4 deg for the bottom for the ten fans and two fans, respectively. It is impossible to say whether the difference was due to the fans or faster cooling in the latter car because of higher initial temperatures.

It is difficult to compare the performance of the various fans because of the variation in factors involved, amount of ice in bunkers, initial temperatures of fruit, length of time operated, and whether or not salt was used. That fairly rapid cooling is possible with all of them is borne out by tests on cars 11 and 12 with ten 12-in, 1200-rpm fans, on car 13 with ten 12-in, 1800-rpm fans, and on car 17 with two 18-in fans. The importance of bunkers being nearly full when the fans are started is shown by the difference in results obtained on car 13 with ice down 24 in with those obtained on cars 14, 15, and 16 with ice down 40 in or more. It would seem that bunkers should be nearly full when precooling is started to insure maximum reduction in temperatures.

Precooling and its relation to quality and distribution will be continued in 1935. The records for 1933 and 1934 indicate that midwestern perishable products can be more effectively distributed by precooling the fruit at loading points. By quickly cooling perishables ripening processes are retarded, more mature products can be loaded, and these arrive at destination in a more salable condition.

Dams or Ponds to Conserve Water

By L. F. Livingstone[1]

UNTIL SUCH TIME—(if ever) that periods of drought can be forecasted, the farmer should be prepared to combat water shortage whether the need arise or not. Obviously the thing to do is to conserve water by storing it when it is available against the time when it may be sorely required. This may be done by means of dams, where there is a stream, or by making ponds or water holes or "tanks."

A pond up to 40 ft in width and of any desired length, and varying in depths from 2½ to 4½ ft can be made by blasting, using the cross-section method of loading. In general, this method consists of putting down a center line of "connector" holes extending for the length of the pond, and parallel rows, 36 in apart, across the width of the pond for its entire length. Holes are spaced 18 in or 24 in apart in a row, the latter for 3-stick loads under very favorable conditions. The holes vary in depth according to the depth of pond desired and the quantity of dynamite required to give that depth. Ditching dynamite is the explosive used, and the loads range from a single stick to three sticks per hole. It is important that the upper end of a single stick or that of the top stick of two or three sticks be not more than 4 to 12 in below the surface. Unless there is enough water on the surface or in the ground to fill up the loaded holes, it is always necessary to use mud or some other tamping material.

Another essential requirement of cross-section shooting is that the earth be sufficiently wet, since the blasting must be done by the propagated method. This method depends upon water in the ground to act as the vehicle whereby the "explosion wave," set up by the explosion of the initial hole, is transmitted to all others. As is generally known, in shooting by propagation, it is necessary to prime only a single cartridge of dynamite in but one hole of an entire series. The primer may be an electric blasting cap—requiring a blasting machine to fire the cap—or the primer may be a blasting cap and fuse.

For blasting a pond 40 ft wide and 3½ ft deep make a single row of holes along the center of the area to be blasted, and for its length. Space the holes in this row 18 in apart. At every other hole make a cross row of holes, with nine holes at 18-in intervals, on either side of the center line. This will give parallel rows of holes, extending the width of the pond area and spaced 36 in between rows. All holes should be two feet deep.

Load all the holes in the area to be blasted, using two sticks of dynamite for each hole. Prime a stick with a blasting cap and use it as the top stick in one hole on the center line. If a cap and fuse are used for priming, care should be taken to see that the fuse is sufficiently long. Preferably the primed hole should be the end one or near the end of those of the center-line row.

Where an electric blasting cap is used, any hole of those on the center line may be primed, as the wires from the blasting machine can be long enough to permit the blaster to take a safe distance. The primed stick must be the last one loaded, to avoid possibility of a premature explosion while the other holes are being loaded.

The detonation of the primed hole will start the process of propagation, with the result that the entire area will be blasted at one time, in what will appear to be the simultaneous explosion of the dynamite in all the holes.

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Agricultural Engineering Digest

A review of current literature by R. W. TRULLINGER, senior agricultural engineer, Office of Experiment Stations, U. S. Department of Agriculture.

VENTILATION OF CROP STORAGES AND COW STALLS [trans. title], *Matschinsky*. Gsndhts. Ingen., 56 (1933), no. 49, pp. 582, 583, figs. 4. Ventilation apparatus is described and data presented briefly for use in the design of air intakes and outtakes.

ADAPTABILITY AND COST OF ELECTRIC HEAT FOR GREENHOUSES, *G. N. Hawley*. Elect. West, 72 (1934), no. 3, pp. 22, 23, figs. 2. Brief information is given on the assembly of electric heating systems for greenhouses.

CENTRAL SOIL HEATING BY MEANS OF LOW PRESSURE STEAM OR HOT WATER USING A HOT WATER HEATER AND CIRCULATING PUMP [trans. title], *W. Zimmermann*. Gsndhts. Ingen., 56 (1933), no. 51, pp. 601-605, fig. 1. Data are presented for use in the design of steam and hot water systems for the heating of greenhouse and hotbed soils.

INSULATED COMMON STORAGE FOR APPLES, *E. R. Gross*. New Jersey Stas. Circ. 301 (1934), pp. 4, fig. 1. Practical information is given on the subject, together with a detailed drawing of the wall construction.

RECONNAISSANCE EROSION SURVEY OF THE BRAZOS RIVER WATERSHED, TEXAS, *H. V. Geib* and *I. T. Goddard*. U. S. Dept. Agr., Misc. Pub. 186 (1934), pp. 47, figs. 31. This publication presents the results of a reconnaissance erosion survey of an area of a little more than 27,000,000 acres comprising 70 counties and parts of counties lying within the Brazos River watershed in Texas. The survey was made in cooperation with the Texas and Oklahoma Experiment Stations.

EROSION AND TERRACING. Puerto Rico Sta. Rpt. 1933, p. 23. The progress results of the operations to prevent the erosion of station lands are briefly presented.

THE STRENGTH PROPERTIES OF SMALL BEAMS (MATCH STICK SIZE) OF SOUTHERN YELLOW PINE, *C. C. Forsaith*. N. Y. State Col. Forestry, Syracuse Univ., Tech. Pub. 42 (1933), pp. 38, figs. 8. Studies are reported the purpose of which was to determine if differences in strength of loblolly pine might be correlated to some degree with variations in orientation and anatomy as well as in density and moisture content. For this purpose a wood was selected with pronounced anatomical variation from which test beams were cut to small dimensions in order that anatomical differences might be large in comparison with overall dimensional values. The methods of testing used very closely paralleled standard procedure.

Three types of beams were prepared: (1) Those consisting wholly of spring wood or of summer wood, (2) those from the same or different increments with one spring wood face and one summer wood face, and (3) those from two rings with a more or less centrally placed band of summer wood flanked on either side by surface bands of spring wood.

It was found that the neutral plane will not occupy a median position in small beams consisting of spring wood and summer wood when the pressure is applied to the tangential surface of the wood. Its position will be determined by the volume and the density of these two types of tissue. A shift of the neutral axis tends to increase the stresses in the spring wood and to decrease those which develop in the summer wood. In southern yellow pine the summer wood appears to be stronger in compression than the spring wood in tension. The difference between the ultimate strength in tension and compression is greater in spring wood than in summer wood.

Small beams in which one face consists of spring wood and one of summer wood are strongest when the pressure is applied across the radial face of the wood, and weakest when the pressure is applied across the tangential face of the spring wood (the L-type of loading). The fiber stress at the elastic limit approaches nearest to the ultimate strength when the pressure is applied to the tangential face of the summer wood (the U-type of loading).

Stiffness is more or less controlled by the summer wood. Wood formed during the early life of a tree appears to be weaker but less brittle than that produced during the later years. At the point of maximum stress local differences in structure, if they be large in comparison with the overall dimensions of the beam, may influence its strength to a greater degree than the specific gravity, and strength and density may not be proportional. The type of failure in small beams will be determined by their orientation in respect to the load, especially in those cases where the pressure is applied to the tangential surface of the wood. When the spring wood is uppermost, they will fail by compression, and when the summer wood is uppermost they will fail by tension and longitudinal shear along the grain. The location of the maximum stress, even to within the length of a few microns, is generally more important in determining the line of failure than are variations in structure such as rays and pits. The line of fracture, except in the thin-walled tracheids, tends to follow the middle lamella, and where it crosses from cell to cell it tends to follow around the margin of the pit flange rather than through the orifice. The compression failure under the bearing plate extends only to the depth of a few cells. Compression failures in spring wood result from a buckling of the tracheid walls, and in the summer wood from a split in the middle lamella. Spring wood tracheids failing by tension exhibit a smooth transverse surface of the brash type, while the summer wood tracheids show a splintered type of failure.

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE OHIO STATION *G. W. McCuen, E. A. Silver, R. C. Miller, C. J. Willard, V. L. Overholt, D. Comin, H. D. Brown, C. O. Reed, R. M. Salter, Young,* and *N. R. Bear*. Ohio Sta. Bul. 532 (1934), pp. 86-92, 102-104, figs. 2. The progress results are presented of studies on rubber tire equipment for tractors, wheel equipment for farm wagons or trailers, wear on plowshares, threshing machines, chopped hay, baling hay from the windrow, subirrigation drainage, fertilizer application with corn planters, and erosion control.

CHOOSING AND OPERATING ELECTRIC STOVES, *A. E. Baragar* and *E. B. Snyder*. Nebraska Sta. Circ. 47 (1934), pp. 22, figs. 22. This circular discusses electric stoves and presents information to aid in choosing and operating such equipment. It is based on Research Bulletin No. 68 of the station.

DETERMINING TONNAGE OF HAY IN STACKS, *R. L. Adams*. California Sta. Bul. 570 (1934), pp. 26, figs. 2. The results of a study conducted in cooperation with the U.S.D.A. Bureau of Agricultural Economics are reported in which more than 1,000 measurements of 563 stacks of hay were made and final weights determined of 364 of these stacks in order to check the accuracy of prevailing methods of estimating the tonnage of haystacks.

A study of the quartermaster and Frye-Bruhn rules, the two principally used in California, indicates that on an average they will give results within 99 and 88 per cent, respectively, of actual volume of stacks. Results obtained with the quartermaster rule, however, may be in error as much as 0.1 to 23.8 per cent, and with Frye-Bruhn rule from 5.4 to 20.8 per cent of actual volume of stacks.

The decimal rule, developed during the course of this investigation, is a refinement of the Frye-Bruhn rule, and for measuring square, flat-topped stacks is expressed by the formula $V = [(0.56 \times O) - (0.55 \times W)\ W]\ L$, in which O is the measurement of the over, W the width, and L the length of the stack. When stacks are measured in feet, to the nearest half foot, the results obtained by use of this formula give close approximations of the actual volume of stacks.

It was found that the volume of most stacks decreases steadily with aging, but the rate of decrease is not uniform because of the factors of kind of hay, maturity when cut, moisture content when stacked, amount and kinds of weeds, height of stack, method of stacking, rapidity of drying hay in stack (influenced by size and shape of stack and atmospheric conditions), and rainfall.

On an average the rate of shrinkage was found to be 8.3 per cent from 1 to 2 mo after stacking, 7.9 from 2 to 3 mo, 6.5 from 3 to 4 mo, 10.3 from 4 to 5 mo, 14.0 from 5 to 6-8 mo, 27.4 from 1 to 6-8 mo, and 20.7 per cent from 2 to 6-8 mo after stacking.

Stacks tend to shrink in height only, little change taking place in either width or length. Wide variation was found to exist in the number of cubic feet which comprise a ton of hay. The average cubic feet per ton for 139 stacks of grain and volunteer hay was found to be 666 cu ft, with 696 cu ft for the greatest frequency group. The average cubic feet per ton for 225 stacks of alfalfa

was found to be 448 cu ft. Studies of various factors, however, show the difficulty of indicating any single figure likely to be acceptable for general use.

When a need arises for determining the contents of stacks by some formula, in lieu of weighing, if the measurements of width, over, and length are known and a figure indicative of the number of cubic feet per ton determined, then much of the task of calculating can be avoided by use of the basic tables presented. The tables and chart provide a means for quickly and easily determining (1) the cross-section area of the stack, (2) volume, and (3) tonnage.

Suggestions to guide in measuring stacks stress the necessity of building stacks as evenly as possible, and the exercising of care in taking the required measurements.

The final conclusion is that there is no entirely satisfactory substitute for weighing, but when reliance must be placed on the use of some formula then the decimal rule is advocated as a means of determining volume. From this determination the number of tons can be ascertained once a figure has been reached indicative of the number of cubic feet comprising a ton of hay. Aids designed to assist in the calculating of the cubical contents of stacks by this method eliminate the necessity of laborious calculations.

PROLONGING PLOWSHARE SERVICE, *H. Beresford* and *E. N. Humphrey*. Idaho Sta. Bul. 202 (1934), pp. 8, figs. 4. The results of tests on the stelliting of plowshares are briefly reported in which three outfits plowed 200 acres.

For the first trial, which was made in the spring, one treated share was placed between two untreated shares on a tractor gang plow and a record kept of the operation of the plow. In the fall two outfits were tested—one a four-bottom tractor gang plow and the other a three-bottom gang plow drawn by horses. Record was taken of the maintenance required for the shares before and after the alloy treatment. The soil was dry, and in the case of the horse-drawn gang plow conditions were very severe. The soil was composed of decomposed granite rock.

In the first test with the single share ¼ lb of alloy was applied. The plow was used in Palouse clay loam, plowing 7 to 8 in deep and averaging 10 acres per day for the outfit. The original shares were identical except for the alloy treatment of the one. Two shares each were used on two bottoms of the gang plow, plowing against the one treated share on the remaining bottom. Before any servicing became necessary on the treated share, the others had been sharpened four times.

In the tests in which the plow was drawn by horses, before the alloy treatment was used, the shares were sharpened and pointed every other day at a cost of 43.8 c per acre. After treatment with 44/100 lb of alloy per share, 74 acres were plowed at a cost of 16.3 c per acre for the treatment. If the time and labor spent changing shares and taking them to town to be sharpened is considered along with the better performance of the plow and the decreased depreciation due to the greater wear on the untreated shares, the saving in plowing costs is between 30 and 50 c per acre in favor of the alloy treatment.

Information is included on the method of applying stellite.

GUIDE TO THE GRADING OF STRUCTURAL TIMBERS AND THE DETERMINATION OF WORKING STRESSES, *T. R. C. Wilson*. U. S. U. S. Dept. Agr., Misc. Pub. 185 (1934), pp. 27.

This circular presents a generalized system for specifying the features that affect the strength of timbers, together with a procedure for determining the working stresses appropriate to any grade. With the help of the data given, individual pieces or lots of timber can be graded by the user or distributor, grade descriptions can be prepared by the lumber manufacturer or user, and working stresses for grades described in lumber association rules or elsewhere can be determined or checked by the engineer, architect, or contractor.

Part 1 presents grade descriptions in blank. Only paragraphs relating to features that affect strength are included. Part 2 supplies data to fill the blanks and makes the descriptions applicable to grades having strength ratios as desired. Details in which part 1 differs from American lumber standards are indicated by italics and are commented on in footnotes. Part 3 discusses topics related to grading for strength, part 4 shows how to determine the working stress appropriate to a grade, and part 5 evaluates existing commercial grades.

THE PRESERVATIVE TREATMENT OF SHADE TENT POLES, *H. W. Hickok*. Connecticut (New Haven) Sta. Bul. 359 (1934), pp. 373-377, fig. 1. The results of a series of experiments are reported in which wood of several native species was given full pressure treatment, open-tank (hot and cold bath) treatment, brush treatment, and treater dust treatment.

All poles treated by the full-pressure process were sound throughout after five years' service. Unquestionably, pressure treatment will give the best results as far as length of service is concerned. The butts of all but two poles treated by the open-tank method were sound after five years' service in the soil. Brush treatment is entirely superficial and little or no impregnation of the wood results. The butts of all poles set with treater dust in the hole were sound after 5 years' service in the soil. While the cost of this material is quite low, and while the results compare favorably with impregnation treatments after 5 yr, this compound cannot be recommended on account of its extremely poisonous nature.

With the exception of pitch pine, the butts of all poles which were set untreated had become entirely unserviceable at the end of 3 yr. The butts of untreated pitch pine poles were sound at the end of 3 yr but had become unserviceable in 5 yr.

With few exceptions, the untreated tops of popple, gray birch, and red maple poles had become unserviceable at the end of 5 yr. The untreated tops of white and pitch pine poles showed very little indication of decay after 5 yr. The tops of all poles which had either an impregnation treatment (full pressure) or a superficial treatment by brushing or dipping were, with very few exceptions, sound and serviceable at the end of 5 yr.

These results indicate that the tops of poles need some kind of preservative treatment to maintain a balance of life between top and butt. Heavy impregnation of tops such as is secured by pressure treatment probably involves an unjustified expense. Moreover, pressure treated poles are likely to bleed in warm weather, especially if tar is used, and this may prove injurious to tobacco. A superficial treatment of tops by dipping or brushing in an open tank treatment of butts has maintained a satisfactory balance of life between top and butt for a period of 5 yr. Poles treated superficially do not bleed unduly.

From the standpoint of physical properties, abundance, adaptability to treatment, and demonstrated results, pitch pine and red maple seem to best fulfill the requirements for tobacco poles. However, from more recent experiments, for which there are at present no service records available, it would seem that the several species of oak and red and scotch pine may also be sources of pole material.

DAIRY REFRIGERATION ON RURAL ELECTRIC LINES, *E. C. Easter* and *M. L. Nichols*. Alabama Sta. Bul. 241 (1934), pp. 12, fig. 1. This bulletin reports the results of studies made as a part of the experimental work on rural electrification conducted in cooperation with the Alabama Power Company and with dairymen in different sections of the State. The work was based upon studies of the requirements for proper refrigeration of dairy products, as determined by bacteriologists and public health officials. Its objects were to study (1) small dairy refrigeration units and results obtained from their use and (2) the adaptability of electrically operated equipment to the refrigeration needs of the dairies.

Electrically operated refrigerating equipment was found to meet the requirements for satisfactory dairy refrigeration when machines of sufficient capacities were properly installed. Sufficient capacity of refrigerating equipment was found to be very important for complete refrigeration and efficient operation. Retail dairies, for complete refrigeration, should have a plant with a minimum capacity of 15 lb ice-melting capacity per 24-hr operation for each gallon of milk produced per day. Wholesale dairies, for complete refrigeration, should have a plant with a minimum capacity of 10 lb ice-melting capacity per 24-hr operation for each gallon of milk produced per day. By circulating fresh water through the upper sections of the tubular cooler, the minimum capacity of refrigerating equipment for retail dairies can be reduced to 12.5 lb ice-melting capacity per 24-hr operation for each gallon of milk produced per day, and for wholesale dairies the minimum capacity can be reduced to 7.5 lb ice-melting capacity for each gallon of milk produced per day. The refrigerating equipment must have sufficient capacity for complete refrigeration without operating more than 18 hr per day.

The most important single factor affecting both the efficiency and cost of proper refrigeration at the dairy was found to be that of insulation. Poor or inadequate insulation results in incomplete refrigeration at increased cost.

To operate refrigerating equipment for complete refrigeration at retail dairies required an average of approximately 7.6 kwh of electricity per month for each gallon of milk cooled per day. At wholesale dairies the average electrical energy consumption for complete refrigeration was approximately 4.6 kwh per month for each gallon of milk cooled per day.

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE MASSACHUSETTS STATION, *C. I. Gunness* and *R. L. France*. Massachusetts Sta. Bul. 305 (1934), pp. 6, 16, 17. The progress results are presented of investigations on apple storages, apple-handling equipment, fertilizer distributors, milk-cooling equipment, and the indol tolerance of the coli-aerogenes group of bacteria as a possible means of differentiating fecal and nonfecal strains occurring in drinking water supplies. *(Continued on page 122)*

STUDENT ACTIVITIES

Contributed and edited by members of ASAE student branches

Penn State Student Branch News

ALTHOUGH meetings of the Penn State Student Branch of ASAE are scheduled regularly for the second Tuesday evening of each month, several special meetings are called each semester. These additional meetings occur when the branch members wish to avail themselves of the opportunity to meet some prominent man visiting the college, or when important business arises. Occasionally the regular meetings conflict with college functions and must be postponed. The following is a calendar of the Penn State Student Branch meetings for the first semester of this college year:

September 25—Meeting to welcome freshmen. Talks by Prof. J. E. Nicholas, acting head of department, and other members of the staff. Refreshments. Membership for the year totaled 19.

October 23—Talk by Prof. R. U. Blasingame, head of department, about the work of the U. S. Department of Agriculture. Prof. Blasingame has been on leave of absence this year.

November 12—Business meeting concerning proposed trip to the state farm show at Harrisburg. Society dues were collected. Ten members subscribed to AGRICULTURAL ENGINEERING.

December 2—Business meeting at which committees were appointed to investigate and make plans for the proposed farm show trip.

December 11—Talks by Prof. A. W. Clyde and Mr. H. N. Stapleton on the ASAE Power and Machinery Division meeting at Chicago. Also a talk by Mr. Ed. Bonner, midyear graduating senior. Reports of farm show committees and acceptance of plans.

January 15—Talk by Mr. W. H. Wade, vice-president of the Pennsylvania Central Light and Power Company on rural electrification. Mr. C. L. East, manager of line extensions for the same company, also spoke.

January 21—A day at the Pennsylvania Farm Show and Student Branch dinner at Harrisburg, the capitol city.

The trip to the farm show was the major event of the semester. The Pennsylvania Farm Show is considered to be one of the best of its kind in the United States. This year it consisted of about 10,000 competitive exhibits, and 700 booths for the display of all types of farm machinery and equipment ranging from egg beaters to Diesel-powered tractors, all housed under one roof covering a floor space of nearly 10 acres. Besides these attractions, state organizations, such as the 4-H clubs, vocational schools, potato growers, vegetable growers, and poultrymen held meetings in separate rooms in the same building. In short, it is a show including nearly every conceivable thing that interests farmers and their families.

The plan for our group to attend this show was worked out and executed by the students. Transportation for the 200-mile trip was provided for by both students and faculty. The students, several of their parents and friends, and the agricultural engineering staff met in the farm show building at 12:30 p.m., where for the next four hours they visited various manufacturers' exhibits. Previous arrangements had been made by one of the committee for a representative of each company to address the group and point out new developments and problems or features of design pertinent to the various machines displayed. Discussions included tractors, pumps, milking machines, sprayers, roofing, rural electrification, and many other topics.

This is a cast aluminum paper weight designed and made by the "Keystone state" (Penn State) Branch of ASAE as a favor to be given to guest speakers and visitors

Following the farm show tour, the group went to the Y.M.C.A. for a dinner at which Mr. John McKee, executive secretary of the Pennsylvania Joint Committee on Rural Electrification, obliged the Student Branch by acting as master of ceremonies. After a few humorous yet pertinent remarks, Mr. McKee introduced Mr. Leonard J. Fletcher of the Caterpillar Tractor Company, who gave a short but interesting and inspiring talk on the field of agricultural engineering. Other guests who spoke were Messrs. C. C. Bartels and C. A. Matthews, both of the American Zinc Institute; Mr. Joseph Webb of the Philadelphia Electric Company; Mr. Dudley Rice of the West Penn Power Company; and Mr. O. R. Fretz of the Pennsylvania Power and Light Company.

Each of the dinner guests was presented with a cast aluminum paper weight emblematic of the "Keystone State" Branch of ASAE. A cut of the favor is shown. These were made by members of the Student Branch and required considerable ingenuity and work.

The Student Branch feels that this event was carried out in such a successful manner that it will be made an annual occurrence. Everyone going on the trip thoroughly enjoyed it and came back with a better knowledge of agricultural engineering, greater enthusiasm, and stimulated interest in their chosen profession.

A publicity man has been elected by the Branch. His duties are to arrange for ASAE Student Branch news items to appear in both the local and college papers. Also work has been started on the design of an appropriate emblem to be displayed on various bulletin boards for the purpose of announcing Student Branch meetings.

Plans for the second semester call for several out-of-town speakers, papers to be presented by the graduating seniors, and an exhibit for the Ag. Carnival. These are only partial plans for the remainder of the year. A final report will be made after the program has been executed. — E. ROBERT CURRY, *publicity chairman.*

Minnesota Branch Presents Program

ON WEDNESDAY, February 13, the ASAE Student Branch at the University of Minnesota held a joint meeting with ASAE members comprising the group known as the "Minnesota Agricultural Engineers," an announcement of which meeting appeared in a previous issue of this journal.

The students presented, in the form of a skit, a brief account of the training they receive in pursuing the professional agricultural engineering course. It showed a typical scene of several students in agricultural engineering studying in the seminar room of the agricultural engineering building at the University of Minnesota. A man dressed as a farmer appeared in search of one of the professors for the purpose of obtaining help on an erosion control problem on his farm. He was informed that the professor was not in but that perhaps the students could help him with his problem. From then on the conversation centered around problems and studies for which student engineers are trained. In this way the Society members present learned something about the extent and adequacy of the agricultural engineering course and were impressed with the fact that agricultural engineers are the best trained men to fill certain positions previously held by other engineers. Many favorable comments were received, and it was felt that the skit had filled the purpose for which it was given.

Mr. Charles E. Woodward, editor of "Northwest Farm Equipment Journal," who gave an address at this meeting, agreed to print in his publication an article, entitled "Why You Should Hire Agricultural Engineers," which will be prepared by Lester A. Malkerson, president of the Agricultural Engineering Students' Conference.—A. W. CARPENTER, *scribe.*

Idaho Entertains Neighbors

WASHINGTON State College students were guests of the Idaho Student Branch of ASAE December 7. "Spain Before the World War," "Panama Canal Zone," and "Wheat Allotment Survey Work" were the topics of very interesting discussions given during this meeting. Mr. Kulp, advisor for the Idaho Branch, gave a report on the coast conference, held last summer. Approximately twenty men were present, which represents about two-thirds of the total membership of the two schools. Idaho has eleven members at the present time. *(Continued on page 120)*

NEWS

Pacific Coast Section Meeting

The Pacific Coast Section of the American Society of Agricultural Engineers will hold its usual spring meeting this year on April 5 and 6, in Bellview School at Porterville, California. The program for this meeting follows:

FIRST DAY — FRIDAY, APRIL 5

FORENOON SESSION—10:30 to 12:00

R. Earl Storie, presiding

PAPER: "Overhead Irrigation"—J. E. Christiansen, assistant irrigation engineer, University of California

PAPER: "Soil Surveys as an Inventory of Soil Resources"—Macy H. Lapham, inspector district 5, Division of Soil Survey, U. S. Department of Agriculture

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Luncheon—12:00 to 1:30

* * *

AFTERNOON SESSION—1:30 to 4:30

R. Earl Storie, presiding

PAPER: "Effect of Burning Grass and Brush Cover from Grazing Lands"—C. J. Kraebel, senior silvaculturist, California Forest Experiment Station

PAPER: "General Aspects of Erosion on Agricultural Lands"—H. E. Reddick, regional director for California, Soil Erosion Service, U. S. Department of the Interior

PAPER: "Water Requirements of Cotton"—L. N. Brown, assistant irrigation engineer, University of California

EVENING PROGRAM—6:30

Section Dinner

R. Earl Storie, presiding

Boulder Dam. A moving picture and lecture on the construction of this engineering masterpiece, by Irvin H. Althouse, engineer, Irrigation Equipment Engineering Company

* * * *

SECOND DAY — SATURDAY, APRIL 6

FORENOON SESSION—9:30 to 12:00

Irvin H. Althouse, presiding

PAPER: "Mechanical Equipment for Grape Leaf-Hopper Control"—O. C. French, assistant agricultural engineer, University of California

PAPER: "The Use of Colored Light in Electrocuting Traps for the Control of Grape Leaf-Hopper"—W. B. Herms, professor of entomology, and J. K. Ellsworth, assistant in entomology, University of California

PAPER: "Gas Engines for Pumping Irrigation Water"—(Speaker to be selected)

* * *

AFTERNOON SESSION—1:15

Field inspection of overhead irrigation system at the Hills Brothers orange orchard, under the direction of E. J. Barnes, manager.

News of American Engineering Council

A MOVE toward better coordination of engineering organizations throughout the country was the main outcome of the annual meeting of American Engineering Council held at the Mayflower Hotel, Washington, January 10 to 12. Public affairs committees to be set up in each state will insure a closer tie-in with local societies and sections toward joint action, and will give Council established agencies with which to deal on a state-wide rather than on a local basis, and will fill a gap in the present system of engineering organization.

A new membership plan will enable local societies to join Council at a lower cost. The increase in Council budget for 1935 by one-third over the year previous will strengthen the "Washington Embassy of Engineers and Engineering" in its service to this extended system.

Highlights of Council's annual meeting include a symposium of federal work by prominent Washington officials, evidence of increasing interest of national societies in work of Council, and a concurrent meeting of the secretaries of engineering societies. Engineering groups in forty-one states were represented. Another assembly is scheduled for October, bringing in boards of control from national societies.

The new membership plan adopted at this meeting provides (1) a flat rate of nominal dues for local societies, with delegates to AEC meetings arranging their own expenses, and (2) division of the country into nine districts so that a group of societies in each may send a joint delegate with expenses paid by Council. Individual societies under a joint membership plan, however, may send delegates at their own expense. Adoption of this new membership plan automatically brought into Council the Engineers Club of Philadelphia and the Engineering Societies of New England. At least a dozen others have indicated their intention of joining Council, and such societies or individuals interested should communicate with American Engineering Council, 744 Jackson Place, Washington, D. C. It should be said in passing that the new plan was devised with the hope of making Council more truly representative of the profession as a whole by attracting local societies.

Another decision made at the AEC annual meeting in the direction of continuing and extending the work of Council, provides a public affairs committee in each state made up of key men from local societies and sections of national societies. This plan does not contemplate the creation of state councils, but rather the setting up of central groups to represent engineers throughout the state in public matters of moment to the profession and to cooperate with national activities of Council. The present AEC Public Affairs Committee is to be divided into subcommittees with interlocking membership in similar bodies of the various engineering societies toward unified action. Other resolutions adopted at this meeting included (1) continued support of the national mapping program, (2) consideration of centralizing rural electrification studies in the Bureau of Agricultural Engineering, U. S. Department of Agriculture, (3) support of earthquake studies by the U. S. Coast and Geodetic Survey, (4) opposition to plans for developing the Arkansas River proposed in the last Congress, and (5) AEC cooperation in research work of certain other agencies.

The conferences of secretaries of some forty national, state, and local engineering societies was the first general conference of this group that has been held since 1929. Earlier conferences ran biannually from 1923 until that date. The main purpose of the secretaries' conference was for exchange of successful experience as to society management. The discussion on relief activities among engineers brought out the varied action of societies in assembling private funds or securing public aid for work in relief projects for unemployed engineers. The subject of cooperation was probably the principal theme of the meeting. The subject of interrelation of national and local activities stirred a lively debate as to the needs for simplification and coordination of the existing system of engineering organization. The conference resulted in the pooling of practical experience as to the successes achieved and the difficulties encountered by secretaries in line with their work in the main regions represented.

C. O. Reed Offers Paper on Research Methods

UNDER the title "The Engineering Approach to a Research Problem," C. O. Reed of the department of agricultural engineering at Ohio State University (Columbus) has prepared a most thorough, yet highly readable paper. Prepared originally for presentation to and study by graduate students in an agronomy seminar, it has been mimeographed and is available on request to Professor Reed.

Among other things, he makes plain the differentiation among true research, experimentation, testing, etc. While the major emphasis is on methods of approach, the author proceeds more briefly to deal with solution technique. The subject matter of research contemplated is by no means limited to agricultural engineering, or to engineering at large. Rather it embraces any and all research of a scientific nature, and perhaps even this limitation should be stricken out. Engineering enters rather as a method of applying mental power to a task in hand, with due regard to its efficient employment, the precision and reliability of its results, its activity in suitably defined fields, psychological principles to be utilized, and disturbing tendencies to be avoided, and so on.

A careful reading of this paper may well be urged upon all engineers charged with administrative and other responsibility of a research nature, and also upon many others for whom the clear import of research may have been beclouded through much taking of its name in vain.

ASAE Meeting Plans

CHAIRMAN R. H. Driftmier of the Committee on Arrangements for the 29th annual meeting of the American Society of Agricultural Engineers to be held June 17 to 20 at the University of Georgia, Athens, has announced some of the entertainment features for the meeting.

At the annual dinner on June 19, a caste of from 200 to 250 people comprising the "Big Bethel Choir," from one of the largest negroes churches in Atlanta, if not in the Southeast, will put on a program, entitled "Heaven Bound." ASAE members attending the meeting have the assurance of hearing some of the finest negro singing on this progrm that they have ever heard.

As to the annual dinner, the Committee writes "Our culinary artists are going to give them a dinner they will be talking amout for the next ten years." It will be a real southern dinner, and there will be plenty of it, though the cost will be nominal.

Other entertainment features will include a real southern barbecue, a watermelon cutting, and an evening devoted to dancing, including both round and square dances—with an honest-to-goodness orchestra, says the Committee.

Arrangements are being made to take care of men with their wives and families in one of the several dormitories on the University campus. For those men who wish to avail themselves of facilities at Camp Wilkins near the University campus. sleeping quarters may be procured at 25 cents per day. However, inasmuch as only about 100 men can be handled in this building, requests for this type of accommodation should be sent to Mr. Driftmier as early as possible.

New ASAE Members

William P. Blum, Pacific Coast sales representative, Louden Machinery Company. (Mail) 472 Tehama St., San Francisco, Calif.

Parks B. Chappell, junior agricultural engineer, Soil Erosion Service, U. S. Department of the Interior. (Mail) Drawer 250, Spartanburg, S. C.

Clarence C. Chronic, chief engineer, Stover Mfg. & Engine Co., Freeport, Ill.

W. B. Denyes, chief engineer, Eastern Steel Products, Ltd., Preston, Ont., Canada.

Frank A. Donaldson, general manager, Donaldson Company, Inc., 666 Pelham St., St. Paul, Minn.

John M. Downing, agricultural engineer, Soil Erosion Service, U. S. Department of the Interior. (Mail) Rock Hill, S. C.

E. E. Epting, agricultural aide, Soil Erosion Service, U. S. Department of the Interior. (Mail) Box 897, Rock Hill, S. C.

W. R. Friberg, draftsman, Soil Erosion Service, U. S. Department of the Interior. (Mail) 309 Howard St., Pullman, Wash.

Karl Harris, agent irrigation assisant, division of irrigation, Bureau of Agricultural Engineering, U. S. Department of Agriculture. (Mail) 313 N. Third Ave., Phoenix, Ariz.

W. F. Hereth, Northwest Soil Erosion Service. (Mail) 217 N. Almon St., Moscow, Idaho.

Roy C. Ingersoll, President, Ingersoll Steel & Disc Co., 310 S. Michigan Ave., Chicago, Ill.

Mercer Lee, branch manager, International Harvester Co. of America, 580 Whitehall St., Atlanta, Ga.

C. W. McKnight, Secretary, Andelot, Inc. (Mail) Box 118, Fairfield, Conn.

G. A. Meares, assistant agricultural engineer, Soil Erosion Service, U. S. Department of the Interior. (Mail) 42 N. Main St., Greer, S. C.

W. H. Mikell, Jr., agricultural aide, Soil Erosion Service, U. S. Department of the Interior. (Mail) Rock Hill, S. C.

R. A. Owen, Soil Erosion Service, U. S. Department of the Interior. (Mail) 142 Oakland Ave., Spartanburg, S. C.

V. S. Peterson, chief technician and acting director 15 (Iowa) ECW camps. (Mail) 225 Gym Ave., Ames, Iowa.

Fred A. Thompson, Jr., junior agricultural engineer, Soil Erosion Service, U. S. Department of the Interior. (Mail) Drawer No. 250, Spartansburg, S. C.

H. Lee Vanderwilt, salesman-collector, John Deere Plow So. (Mail) 15 Highland Ave., Houlton, Me.

Franklin H. Watson, Jr., agriculturist, East Bay Municipal Utility District. (Mail) Box 61, Lodi, Calif.

Russell Woodburn, assistant agricultural engineer, Soil Erosion Service, U. S. Department of the Interior. (Mail) Spartanburg, S. C.

Applicants for Membership

The following is a list of applicants for membership in the American Society of Agricultural Engineers received since the publication of the February issue of AGRICULTURAL ENGINEERING. Members of the Society are urged to send information relative to applicants for consideration of the Council prior to election.

Emilio Gomez Ayau, chief engineer, Provincial Service of Agrarian Reform, Seville, Spain.

Harry P. Bateman, engineer foreman, ECW Camp 75-DPE, Macomb, Ill.

Dale L. Bidwell, technical foreman, ECW Camp, Soil Erosion Service, U. S. Department of the Interior. (Mail) Box 131, Lindale, Tex.

Sidney C. Buckaloo, junior agricultural engineer, Soil Erosion Service, U. S. Department of the Interior. (Mail) Ridgeway, Mo.

John R. Carreker, agricultural engineer. Soil Erosion Service, U. S. Department of the Interior. (Mail) Dadeville, Ala.

Donald Christy, assistant agricultural engineer, Soil Erosion Service, U. S. Department of the Interior. (Mail) Wadesboro, N. C. (Transfer of grade)

William V. Harlin, junior agricultural engineer, Soil Erosion Service, U. S. Department of the Interior. (Mail) Dadeville, Ala.

Frederick G. Krauss, director, agricultural extension service, University of Hawaii, Honolulu, T.H.

Charles M. Sanders, junior agricultural engineer, Soil Erosion Service, U. S. Department of the Interior. (Mail) Dadeville, Ala.

Robert H. Vahrenkamp, planning engineer, ECW Camp, Soil Erosion Service, U. S. Department of the Interior. (Mail) Box 141, Lindale, Tex.

Student Activities

(Continued from page 118)

Plans are now moving forward in preparation for a big time when the Oregon State Branch makes its visit here at Idaho, possibly in March. Considerable federal work has been going on in this vicinity, which offers wonderful opportunity for study. The Oregon group are making a visit to investigate soil erosion methods. It has been suggested that this visit by Oregon State might offer a good opportunity for a conference, including Idaho, Washington State, and the visitors. Nothing definite has yet been decided, but such a conference would do much to create interest in all groups concerned. In any event, Idaho is looking forward with pleasure to this visit by Oregon State.—WILLIAM WATSON, *scribe.*

Georgia Heard From

THE MEMBERS of the Georgia Student Branch of ASAE were entertained at the expense of thirteen new members at the last meeting of January. These new members were put through the initiation set up by the chairman of the program committee. It is certain that thirteen new members will await the next initiation with thoughts of revenge and pass on the tradition to the next class of freshmen.

Officers elected at the last meeting of January to serve until next May were James C. Tillman, president; George Bell, vice-president, and H. V. Wright, secretary and treasurer. DAN NORTON, *Scribe.*

NOTE: Dan Norton, Georgia's scribe, says to tell all the fellows interested in coming to the Agricultural Engineering Students' Conference this coming June at Athens, to leave their overcoats at home. The grass is greening and trees budding already at this early date (February 15).—Charles Schlotterbeck, news chairman.

Ohio State Branch News

SIXTY STUDENTS, both members and visitors, attended the winter quarter "Open House" meeting of the Ohio State Student Branch of ASAE, Thursday, February 14. Business consisted of a report on the returns of the Farmers' Week lunch counter. This was rapidly disposed of and the remainder of the evening given over to the entertainment committee.

A moving picture, entitled "Beautiful Ohio," and a comedy strip were the first features of the program, presented through the courtesy of one of the Ohio oil companies. After the show, group singing led by one of the students and a few tricks on the professors completed a well-rounded evening of entertainment.

Refreshments consisting of pop corn and apples were served in "help yourself" style, everyone leaving the meeting with a full stomach and some with full pockets. (The refreshments committee had to have help to dispose of the extra apples, so everyone heartily cooperated.)

7 YEARS of "CATERPILLAR" PROGRESS

makes *Terracing* cost no more than a good plowing job

In 1928, "Caterpillar" Tractors were proving their fitness as terrace-builders with disks, ditchers and one-way plows—helping agriculturists in many states initiate soil-saving programs. This 2-Ton had everything licked, then!

1929, and "Caterpillar" Graders, hitched to "Caterpillar" Tractors, roll on to lower terracing costs. This 10-hp "Caterpillar" was used on an experimental farm of Kansas State College, Manhattan.

1930 sees the movement for Soil Erosion Control gaining momentum—and "Caterpillar" designers weren't napping! That's the year the "Caterpillar" No. 1 Terracer with gooseneck hitch arrived—a specialized, big-capacity tractor machine that nicked another dollar from the per acre terracing costs. Center view shows the No. 1 at work near Washington, D. C.

THEN came the "Caterpillar" Diesels with their unprecedented operating economy, and late in '33, the No. 33 Leaning Wheel Terracer in answer to demands for a machine of this type to team with the 40-hp Diesel Tractor. Sentiment for a leaning wheel terracer promptly expired when "Caterpillar" engineers proved that straight, not leaning wheels are required to back a 2-wheel machine accurately — and that the terracer operator faces an impossible task trying to lean wheels properly on slopes varying greatly in short distances.

1934 therefore brought the No. 2 Terracer, developed and thoroughly proved, for the "Caterpillar" Diesel Forty Tractor. Watch it roll a furrow—it's the balanced combination that builds complete terraces in one-fourth the rounds the 1928 outfit took, and for one-third the dollars per mile! It represents the seven years of practical experience working with terracing authorities of every region.

Behind the "Caterpillar" Diesel Forty and the "Caterpillar" No. 2 Terracer, erosion control projects are growing like a snowball rolling down hill!

* * *

Ask for the "Caterpillar" Book "Crops Or Canyons" —an authentic, well-illustrated publication showing erosion control methods, equipment and results.

CATERPILLAR TRACTOR CO.
PEOR A, ILLINOIS, U.S.A.

Agricultural Engineering Digest

(Continued from page 117)

THE USE AND EXPENSE OF FARM IMPLEMENTS, *G. B. Byers* and *B. T. Inman*. Kentucky Sta. Bul. 345 (1933), pp. 233-258. This report presents a description of the use and analysis of the investment and expense of farm implements on 101 farms in Christian and Todd Counties for the farm year 1930.

Farm implements represent 3.5 per cent of the farm investment for the state and 4.6 per cent for the farms studied. The total current implement expense on these farms was 8.4 per cent of the current farm expenses for 1929. Over ninety different kinds of implements were reported on the 101 farms. The wagon was the only implement found on all farms. The total days of service during the life of most implements was short. This was largely due to the short seasonal use of many implements. Depreciation represented 47.7 per cent of the total annual expense of farm implements on the 101 farms, repairs 22.4 per cent, interest 17.8, housing 4.6, oil and grease 4.6, insurance 2, and taxes 0.9 per cent. Since depreciation, the largest single item of expense, was not proportional to annual use, increased annual use reduced the unit expense. Forty-five tractors showed an average annual use per tractor of 28.8 days, of which 65.2 per cent was drawbar work and 34.8 per cent belt work. The drawbar expense averaged 81 c per hour and belt work 72 c per hour. The expense of tractor operation per acre covered varied from 24 c an acre for pulling the rotary hoe to $1.12 an acre for breaking ground.

The expense of farm implements was influenced by size of farm, days of annual use, type of operating labor, use of repair shop, and housing, purchasing and discarding practices. Size of farm and annual use are closely related in their effect upon the economical use of implements, as shown by the general decrease in unit expense as use increased. The acreage increase should be of such a size as to make the fullest use of the implements that have to be duplicated. Where it was not possible to make the fullest use of the added machines the expense was increased and the operator did custom work as a means of controlling this increased unit cost. The hourly operating expense on the tractor decreased 99 c with an increase in annual use from 106 to 485 hr. A further increase in annual use showed only a slight decrease in expense. The annual expense for 9 binders that harvested an average of 14 acres was $1.03 compared to 31 c an acre for 7 binders which harvested 76 acres annually.

The study indicated that hired labor increased the annual implement expense.

The farm repair shop made possible a saving of $5.47 in expense for each $100 of implement investment by the use of 1.25 hr of additional farm labor. Implements that were made of wood and the more complicated machines were housed all the year except during the working season. A study of the effect of housing upon the mower showed a saving of 7.7 c an acre covered when the machines were housed. The proper selection and adaptation of implements to the farm needs determine to a considerable extent the service secured. Sixty-two implements were discarded because they were not needed, though still in working condition. Forty implements were discarded because they were not adapted to the work.

REPORT OF TRUCK FIELD TESTS IN CANLUBANG, LAGUNA, USING A-ALKOHL MOTOR FUEL NO. 1, B-DEHYDRATED ALCOHOL, AND GASOLINE AS FUELS, *A. L. Teodoro* and *J. P. Mamisao*. Philippine Agr., 22 (1934), no. 10, pp. 720-744, figs. 2. Field data from tests made on a sugar estate on the use of alcohol fuels in motor trucks are reported. The objects of the study were (1) to determine the average economy of such fuels as A-alkohl motor fuel No. 1, B-dehydrated alcohol, and gasoline under different conditions; (2) to measure engine wear and degree of carbon deposit in the combustion chamber; and (3) to study the behavior of the engines when different fuels are used. Six trucks of the same make and length of service were used. The constituents by volume of A-alkohl motor fuel No. 1 are: Alcohol (about 95 per cent by volume) 90 per cent, gasoline 0.5, and aniline 0.5.

The field tests showed that all other things being equal the shorter the hauling distance the shorter is the average mileage per given volume of fuel. A considerable amount of fuel is used unnecessarily by frequent starting and stopping of engine and by habitual running on first gear, second gear, and reverse. The fuel consumption on level ground and on good roads is less than on plowed field and on rolling areas.

The use of different engines of the same make and nearly of the same age under nearly the same Canlubang conditions pointed to the conclusion that with the carburetors adjusted to give satisfactory operation on different fuels the consumption of gasoline was least, A-alkohl motor fuel No. 1 next, and B-dehydrated alcohol the greatest. These results were based upon the weighted averages of more than 1,000 tests. Considering the consumption with gasoline as 100 per cent, A-alkohl motor fuel No. 1 had 102 to 103 per cent and B-dehydrated alcohol 110 per cent when up-draft carburetors were used. With down-draft carburetors the percentage for A-alkohl motor fuel No. 1 was from 150 to 178 per cent, and for B-dehydrated alcohol from 145 to 160 per cent.

The use of different fuels for the same engine indicated that, all other things being equal, gasoline was first in miles per gallon and A-alkohl motor fuel No. 1 last. With the mileage per unit volume of A-alkohl motor fuel No. 1 as a basic unit, the equivalent averaged amounts for dehydrated alcohol and for gasoline were, respectively, 1.078 and 1.909 with up-draft carburetor and 1.320 and 1.932 with down-draft carburetors. The averages were nearly 1.2 for dehydrated and 1.9 for gasoline.

Considering the average wear per 1,000 km of travel and using A-alkohl motor fuel No. 1 as basic unit, the ratios for gasoline and for B-dehydrated alcohol were, respectively, 1.54 and 2.19 with up-draft carburetor and 0.40 and 0.49 with down-draft carburetor. The exceptionally high piston ring wear, as shown by the truck using alcohol with up-draft carburetor, might be due to the fact that the engine was newer by about 500 km than the others tested.

The carbon deposit reduced to grams per 1,000 km was least in A-alkohl motor fuel No. 1 and largest in B-dehydrated alcohol. The cooling water temperature was never beyond the normal requirement during any of the tests. B-dehydrated alcohol indicated higher averages than either A-alkohl motor fuel No. 1 or gasoline.

Fair operation of the engines was maintained during all the tests. Gasoline fuel was a little better than any of the alcohol fuels in points of flexibility and load pick-up. There was hardly any difference between them in ease of starting. A-alkohl motor fuel No. 1 needed longer time for warming up the engine than either gasoline or B-dehydrated alcohol. No objectionable odors were produced with alcohol fuels when the engines were operated under adverse conditions.

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE TEXAS STATION, *H. P. Smith, D. T. Killough, D. L. Jones, D. Scoates, B. H. Hendrickson, R. W. Baird, R. E. Dickson, and B. C. Langley*. Texas Sta. Rpt. 1933, pp. 115-117, 138-143, 175-177. The progress results are briefly reported of investigations on the mechanical harvesting of cotton, efficiency in the distribution and placement of cottonseed and fertilizer, soil erosion, and run-off. The two latter investigations are being conducted in cooperation with the U.S.D.A. Bureaus of Chemistry and Soils and Agricultural Engineering.

RUN-OFF AND EROSION FROM PLOTS OF DIFFERENT LENGTHS. *F. L. Duley* and *F. G. Ackerman*. Jour. Agr. Res. [U.S.], 48 (1934), no. 6, pp. 505-510, figs. 3. Studies conducted at the Kansas Experiment Station are reported which included two sets of experiments. In each, four plats 3 ft wide and 10, 20, 40, and 100 ft long were used. These were surrounded by strips of galvanized iron set in the ground to a depth of 6 in.

There was a 3-ft alley between plats, and the middle of all plats was on a line at right angles to the direction of the length of the plats. By this arrangement the soil conditions in each plat should be representative of those prevailing over the whole of the small area employed in the experiments. The slope of the land was 4 per cent in experiment 1 and 4.4 per cent in experiment 2. The plats used in the first experiment were only about 25 ft south of those used in the second.

The soil in which the tests were carried on is Derby silty clay loam. This soil has a fairly permeable surface soil and the subsoil is a silty clay to clay in the B horizon, but has not developed anything that even approaches a clay pan. The soil and subsoil could, therefore, be considered as having characteristics that would permit rather rapid absorption.

To simulate rainfall most of the water was applied with sprinkling cans, although in a few cases natural rainfall was used. There was a larger percentage of surface run-off from the short plats than from the long ones. This seemed to be true with both the heavy and light applications of water for the plat lengths under consideration.

The results for soil erosion were less consistent. When the rate of water application was light there was a tendency for the erosion from the short plats to run relatively high as compared with the others. When the rate of application was heavy, i.e., 1 in in 15 min, erosion was greater on the long plats. These results indicate that when rainfall is light short plats may possibly undergo the greater erosion, but when rains are heavy the reverse is true.

IRRIGATION INVESTIGATIONS AT THE ARKANSAS STATION. Arkansas Sta. Bul. 297 (1934), pp. 75, 76. Progress results are presented of investigations on duty of water and underground water resources for rice irrigation, including data on cost of pumping.

(Continued on page 126)

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GENERAL ELECTRIC

Agricultural Engineering Digest

(Continued from page 122)

AGRICULTURAL ENGINEERING INVESTIGATIONS AT THE ALABAMA STATION, *E. G. Diseker, M. L. Nichols,* and *H. D. Sexton.* Alabama Sta. Rept. 1932, pp. 7-10. The progress results are briefly reported of experiments with machinery for planting and harvesting oats, and of studies of weed control, methods of curing hay, hillside planting and cultivating equipment, and soil erosion.

DIESEL POWER AND FIELD OPERATING COSTS. Montana Sta. Bul. 289 (1934), pp. 16, figs. 5. The results of experiments are reported which were conducted during the season of 1933, the purpose of which was to throw light upon certain phases of the use of cheap fuels in agriculture. This report deals only with the general nature of the utilization of cheap fuel through Diesel motors, since the experiments so far have covered only a limited number of tests.

It is pointed out that while Diesel fuel is not yet available at local oil stations it can be obtained at nearly every refinery in Montana at a comparatively low price. It was found that the servicing of the Diesel tractor is somewhat different from that of a gasoline tractor, but it offers no particular difficulties as the instructions of the manufacturers are easily understood.

Fuel costs are decidedly lower for the Diesel tractor. The amount of fuel used in the experiments was slightly over half the amount used per unit of work by the same type of gasoline tractor. This, together with difference in price, resulted in a decided saving in cost for operations. A minor saving was apparent in the cost of lubricating oil.

The higher initial price of the Diesel tractor was found to partly offset the savings in fuel through higher depreciation and interest charges, if the same number of working hours is assumed for gasoline and the Diesel tractor.

PNEUMATIC TIRED EQUIPMENT FOR FARM USE, *E. C. Sauve.* Michigan Sta. Quart. Bul., 16 (1934), no. 4, pp. 278-281, figs. 2. Tests of the relation of soil moisture to drawbar pull showed that in the drying process the moisture test of samples of the soil did not change in relation to the advantages gained in drawbar pull. The drying out process of the soil over a period of a single day made a difference of several hundred pounds in pulling ability of the tractor. In sandy loam soils, no difficulty was experienced in getting adequate traction even when the soil was wet and without the use of chains on the tractor.

In the field work which followed throughout the spring and early summer, the tractor performed very well with the exception of an occasional stall after a shower. Fuel and daily duty tests were made with satisfactory results, although it was not possible to make comparisons with steel-wheeled equipment. A considerable amount of the work was accomplished with the tractor in high gear, whereas in former years intermediate or second gear speed was required to pull the same equipment.

Reports on the tractor used in general farm operations were highly satisfactory, particularly in the operation of plowing, fitting, rolling, and cultivating in muck soils, and in harvesting hay and corn crops.

A COMPARISON OF ELECTRIC AND COAL BROODERS IN THE PRODUCTION OF WINTER BROILERS, *J. M. Moore* and *H. J. Gallagher.* Michigan Sta. Quart. Bul., 16 (1934), no. 4, pp. 266-278, figs. 5. Tests are reported in which five houses were used. Houses 1 and 3 were sided with car siding, roofed with roof boards on rafters covered with three-ply roofing, and floored with double floor with single thickness of building paper between rough bottom boards and finished top flooring. Houses 2 and 4 were sided with 0.5-in insulation board between studs and car siding, roofed with 0.5-in insulation between rafters and roof boards, covered with three-ply roofing, and floored the same as houses 1 and 3. House 5 was all metal.

Two 56-in electric brooders with a rated capacity of 350 chicks and three No. 11, 52-in hard-coal burners were used. The electric brooders were equipped with standard equipment—a 440-w heating element, thermostat for heat control, a thermometer for recording the temperature beneath the canopy, and a small light to attract the birds beneath the hover. Natural draft ventilation was used.

Though the adverse weather conditions under which the experiment was conducted were very severe, the birds in all of the five pens came through satisfactorily. The rate of feathering of the birds reared under electric hovers was not as rapid as those reared under coal-burning brooders. With the ventilation system used, the extra cost of insulating brooder houses 2 and 4 was not justified from the standpoint of fuel consumption. During the severe weather conditions, additional auxiliary heat would undoubtedly have helped correct the unfavorable conditions in the electric brooder houses. From a practical standpoint it is considered questionable whether the additional expense would have been justified. The electric brooders were easier to operate than the coal-burning brooders. With feed at $2 per 100 lb, coal at $14 per ton, electricity at 3 cents per kilowatt-hour, and shavings at $9 per ton, there was no profit in producing winter broilers at 26 cents per pound.

IRON STAKES AS SUPPORTS FOR CONIFEROUS SEED BED FRAMES, *J. L. Van Camp.* Michigan Sta. Quart. Bul., 16 (1934), no. 4, pp. 263-266, fig. 1. Iron stakes used for this purpose at the forest nursery of the station are described.

PROTECTION FROM LIGHTNING, *E. R. Gross.* N. J. Agr. [New Jersey Stations], 16 (1934), no. 3, pp. 4, 5. Brief practical information is presented.

THE DESIGN OF WOODEN BOXES, *R. S. Millett.* Canada Dept. Int., Forest Serv. Circ. 39 (1934), pp. 24, figs. 12. Technical information is given on the design of boxes, together with instructions on conducting hazard, compression, and drop tests.

THE NEW JERSEY MULTIPLE-UNIT LAYING HOUSE AND BILL OF MATERIAL, *E. R. Gross* and *H. E. Besley.* New Jersey Stas. Circ. 318 (1934), pp. 15, figs. 3. Summarized and itemized bills of materials are given for this structure, together with suggestions on construction and plan and elevation drawings.

METHODS AND COSTS OF FILLING SILOS IN THE NORTH CENTRAL STATES, *K. H. Myers.* U. S. Dept. Agr., Farmers' Bul. 1725 (1934), pp. II + 22, figs. 5. The purpose of this bulletin is (1) to show the elements of cost involved in filling upright silos by different methods and practices, (2) to show the relative importance of these elements of cost and the factors affecting them, and (3) to present a basis for selecting and combining them in such manner as best to fit conditions on the individual farm.

The study was based on data collected in 1928 and 1929 by the department of farm organization and management, University of Illinois, in cooperation with the U.S.D.A. Bureau of Agricultural Economics. Records of the cost of filling upright silos were obtained on 87 farms in Illinois on which stationary cutters were used and on 118 farms on which field harvesters were used.

It was found that the cost of filling a silo varies with the type of equipment. The average cost in Illinois was $1.49 per ton on farms where stationary cutters were hired, $1.41 on farms where stationary cutters were owned, and $1.31 per ton on farms where field harvesters were used.

Using a field harvester involves substituting power and equipment for part of the man labor used in filling the silo with the stationary cutter. On an average the investment in equipment was more than twice as high and twice as much tractor power was used when the filling was done with field harvesters, but 21 per cent less man labor and 27 per cent less horse work were used. Cash costs made one-half the total when stationary cutters were hired, one-third when they were owned, and one-fourth when field harvesters were used. One of the chief advantages of the field harvester is the possibility of using family labor or labor that could not be used so well around a stationary cutter, thus reducing the total cost and the cash cost of filling.

Literature Received

CROPS OR CANYONS, Caterpillar Tractor Co., Peoria, Illinois. Of the 56 pages comprising this book, five are of distinctly catalog or advertising character, while on fifty pages the word "Caterpillar" can scarcely be found except as it is visible on equipment illustrated in action. So profusely is it illustrated that text matter is mainly in the form of captions. Large halftone reproductions of field photographs predominate, with line drawings and diagrams used to show principles and procedures not adapted to the photographic method. While designed to visualize for nontechnical understanding the need, purpose, and methods of erosion control by terracing, it embodies much authentic engineering, and gives references to still more. Agricultural engineers will be gratified with the appearance of their colleagues in citation, quotation, and even in some of the pictures. While not forbidding in presentation, the need for accurate engineering is implied by such things as the appearance of level and rod. More than ordinary emphasis is given to adequate and permanent outlets. While much of the material is of general application, special attention is given to the Southeast and to the Great Plains. Copies are available on request to the company, or to its distributors.

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Machinery that is dependable—
That stays out of the
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It may cost a slight premium
To use the best
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Find that "Good Will"
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Sturdy Nickel Alloy Steels
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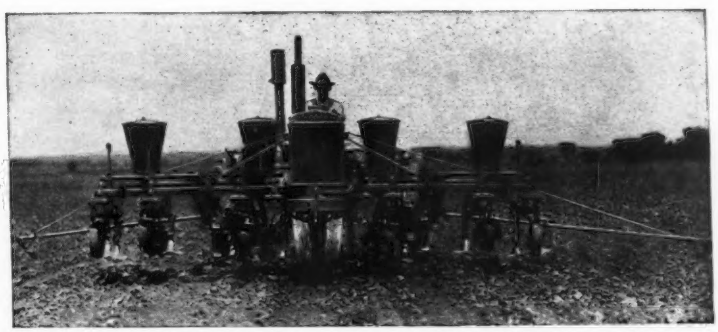

• *Combination planter and cultivator driven by Model MM Twin City Universal Tractor made by Minneapolis Moline Power Implement Co., Minneapolis*

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And highly resistant
To stress, impact, shock,
Abrasion, corrosion and wear

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When you consider
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A 20-Year Record of Farm Machine Improvements

HAVE FARM MACHINES shown marked improvement in quality during the past two decades? The statisticians of the federal government wanted to know. The farm trade was ready to be shown. The agricultural engineers wanted the improvement recorded. Even the manufacturers, who claimed they had made such progress in producing a better product, wanted to know in detail, step by step, and in black and white, what they had actually accomplished. And this is what happened:

1 Arrangements were made to have three well-known agricultural engineers make a disinterested, authoritative study of the engineering development and improvement of twenty-five representative farm machines during the past 20 years. Dr. J. B. Davidson, Iowa State College; Prof. G. W. McCuen, Ohio State University, and Prof. R. U. Blasingame, Pennsylvania State College, are the three engineers who made this study.

2 Not only did these agricultural engineers carefully examine and note the contrast between the farm machines of twenty years ago and those of today, but they also reviewed and recorded step by step the progression leading to the changes made. Also, instead of dealing merely with the machines under consideration as whole units, they examined as well the evolutionary changes in every part of the machines they studied. There was a total of 13,318 items in the 25 machines under consideration, including bolts, rivets, etc.

3 The results of the study were published in a 168-page book (8½ x 11 in), entitled "Report of an Inquiry into Changes in Quality Values of Farm Machines Between 1910-14 and 1932," which includes 64 full-page halftone illustrations showing graphically the changes that have taken place in the principal agricultural machines, and in their working parts.

The report is in four parts, as follows: Part I sets forth the purpose, scope, and conclusions of the inquiry. Part II is a chronological record of important changes in each of the 25 machines during the past 20 years. Part III exhaustively discusses changes in materials used in the manufacture of farm machinery. Part IV contains a direct comparison in detail—by both text and illustrations—of machines of the 1910-14 and 1932 periods.

4 The report of this inquiry was published by the American Society of Agricultural Engineers from which copies may be purchased singly or in bulk.

* * * * *

The price of the "Report of an Inquiry into Changes in Quality Values of Farm Machines Between 1910-14 and 1932," is 50 cents per copy (postpaid), on orders of one to twenty-five copies. Special prices will be quoted on orders for larger quantities. Place order direct with

AMERICAN SOCIETY OF AGRICULTURAL ENGINEERS

SAINT JOSEPH MICHIGAN

EMPLOYMENT BULLETIN

An employment service is conducted by the American Society of Agricultural Engineers for the special benefit of its members. Only society members in good standing are privileged to insert notices in the "Men Available" section of this bulletin, and to apply for positions advertised in the "Positions Open" section. Non-members as well as members, seeking men to fill positions, for which members of the Society would be logical candidates, are privileged to insert notices in the "Positions Open" section and to be referred to persons listed in the "Men Available" section. Notices in both the "Men Available" and "Positions Open" sections will be inserted for one month only and will thereafter be discontinued, unless additional insertions are requested.

Men Available

ENGINEER, experienced on extensive mapping projects, drainage projects, construction projects, and the building of railroads in connection with sugar estates, also experienced with sugar mill and heavy construction and with all forms of hoists, etc., desires employment where his experience may be used. Will go anywhere, but prefers the tropical countries. MA-257

AGRICULTURAL ENGINEER desires position in farm structures or utilities field with college or commercial concern. Graduate of Iowa State College. Experienced in farm structures design, in the promotion and sale of building materials, in orchard work and in the manufacture of tractors. Employed at present. Age 26. Married. MA-258

AGRICULTURAL ENGINEER, with technical training and ten years' experience in general farm machinery operating, designing, and troubleshooting, five years' research and experimental work on cotton pickers and cotton harvesters, desires connection with an equipment manufacturing concern interested in adding cotton harvesting machinery to their line. MA-259

AGRICULTURAL AND ELECTRICAL ENGINEER, with bachelor of science degrees in both agricultural engineering and electrical engineering from the University of Wisconsin, desires employment (1) in rural electrification research with a college or experiment station, (2) in commercial work as rural service engineer or distribution engineer with an electric power company, (3) in development and engineering work with a manufacturer developing and building equipment for rural trade, or (4) in the educational field as an instructor or extension worker. Earned all educational expenses while attending college. Reared on a Wisconsin dairy farm. Two-years' experience in federal erosion control camps in Wisconsin in charge of concrete and construction work in erosion and flood control and land utilization. Assisting in instruction work in the agricultural engineering department, University of Wisconsin, at the present time. Location not important. Age 26. MA-260

AGRICULTURAL ENGINEER with bachelor's degree from University of Minnesota, born and reared on grain and dairy farm in southeastern Minnesota, with experience in large-scale farming in Montana and in artificial hay drying in New York, who knows the propagation, care, and planting of nursery stock and has some experience in erosion control work and in surveying work with the Coast and Geodetic Survey, desires employment for which his training and experience fits him. Age 28. Single. Location not important. MA-261

Positions Open

RURAL SERVICE ENGINEERS needed to fill positions in reorganization of rural electrification department of an electric light and power company. Their duties will be to promote the sale of electrical appliances in the rural areas, negotiate new lines, and work cooperatively with the manufacturers of electrical farm equipment. It is more essential that applicants have a practical knowledge of agriculture than electrical engineering. Salaries at start for these positions will be from $135.00 to $150.00 a month, plus transportation and expenses. Good oportunities for advancement. Write John S. Webb, director, rural sales, Philadelphia Electric Company, West Chester, Pa.